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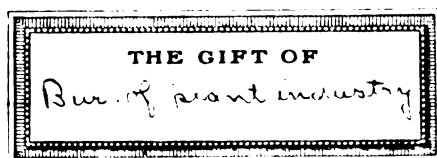
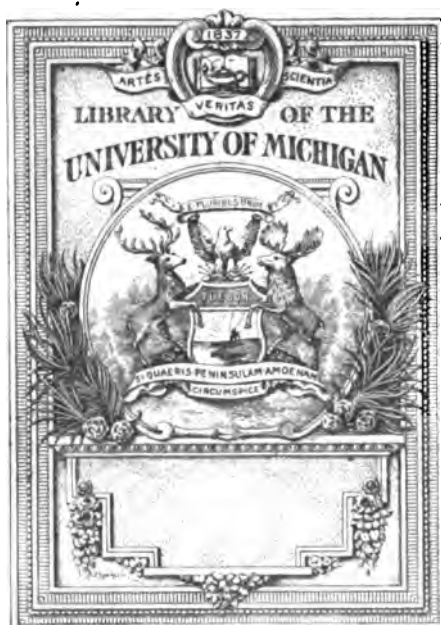
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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 218.

B. T. GALLOWAY, *Chief of Bureau.*

CROSSBREEDING CORN.

BY

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Office of Corn Investigations.

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LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., August 14, 1911.

SIR: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 218 of the series of this Bureau a paper by C. P. Hartley, Ernest B. Brown, C. H. Kyle, and L. L. Zook, entitled "Crossbreeding Corn." This article presents one feature of the work of the Office of Corn Investigations on the project of finding and developing higher yielding strains of corn for different geographical sections of the United States. The success that is being attained along this line is due to the utilization of the effects of acclimatization, adaptation, crossbreeding, and selection.

The results of field tests in four States are given in detail. In this report the results are assembled in a manner to show the relative productiveness of first-generation crosses and their parent varieties. While these results include a part of the data that are being assembled to show the effects on corn of acclimatization and adaptation, only such mention is here made of these influences as will prevent their effects being attributed to crossbreeding.

These investigations assist in determining what varieties and what combinations of varieties can be most profitably grown in different localities. They also assist in revealing the qualities of seed corn that influence its productivity. Knowledge of this nature is especially needed at this time to assist in establishing successful methods of corn improvement embracing the good effects of selecting fine-appearing ears and of crossbreeding, without leading practical corn growers into the belief that prize-winning ears are necessarily profitable seed ears or that a well-selected and well-adapted variety is usually less productive than its first-generation cross.

The results presented here are the first results of a series of tests being conducted with many varieties under various environments. More work more accurately conducted is necessary before general conclusions of a positive nature are warranted, but the urgent need of facts concerning our most widely grown and most valuable crop makes it advisable to publish in detail these results, which are at once of both local and general value.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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CROSSBREEDING CORN.

INTRODUCTION.

In the United States corn has become the leading and most universally grown crop, perhaps more because of its natural adaptability and productiveness than because of any improvement of the plant intentionally accomplished by man. Human efforts have doubtless had a great influence upon the evolution of maize, and it has been modified so as better to meet human needs. These changes, however, have come about probably more because of the interdependent relations that have existed between man and corn than through knowledge intentionally applied. The evolutionary steps that have developed the maize plant as it exists to-day are so little understood that they are of little value in indicating methods to be adopted or avoided in further improving this crop. Such improvement may rest upon a close study of the effects upon the plant of different methods of breeding and a correct application of the principles evolved.

The success of the work of the Office of Corn Investigations in originating and improving high-yielding strains of corn for different sections of the United States has been due to the utilization of the effects of acclimatization, crossbreeding, and selection. Of these three factors crossbreeding is the principal one here under consideration; but as these as well as other factors—such as seasonal and soil conditions—usually operate together in influencing plant growth, the effects of all factors that can not be eliminated must receive consideration whenever comparisons are made.

Because crossbreeding of corn is so readily accomplished, and the results are so varied and interesting, and because crossbreeding is so generally recognized as a very important process in plant improvement, the corn investigations of the Department of Agriculture during 1900 and for several years following consisted very largely in crossbreeding all types obtainable. Of the first-generation crosses tested some were unusually productive, some good, some indifferent,

and some unusually poor producers. The indifferent and poor-producing crosses were discarded and selection work started with the unusually productive ones. As the work progressed some decreased in productiveness while others retained their high-yielding qualities, and a few have come into general culture as the best grain-producing strains of certain localities.

As most of these crosses when tested in various localities were found to be seldom superior to local strains, the improvement of local strains by selection or by crossbreeding and selection combined became a more prominent feature of the corn work. This feature has proved highly satisfactory and profitable to practical farmers, and much experimental evidence has been obtained to demonstrate that strains can be greatly increased in productiveness by centgener selection.

Investigations and observations have indicated a number of lines for the improvement of general practices in seed-corn production. In this connection attention is called to the following points regarding corn: (1) That self-fertilization reduces productiveness; (2) that constant isolation, especially when unaccompanied by judicious selection, may result in the multiplication of undesirable individuals and the augmentation of their undesirable characters; (3) that the emphasis which has unfortunately been placed upon the possibility of improving productiveness by planting fine-appearing, prize-winning ears has reacted against the improvement of yields through the selection of seed from high-yielding individuals; (4) that the adaptation of the floral parts of maize to facilitate crossbreeding has played an important part in its evolution, perhaps assisting in giving it greater vigor, productiveness, adaptability, and freedom from disease than other cereals.

One or more of these features has reduced yields in so many instances where increased yields were expected that some, and especially those who have not witnessed improvement by selection, have become skeptical regarding possibility of increasing yields by selection and desirous of trying radically different methods.

Crossbred seed frequently gives better yields than either parent, especially if one or both parents are poor producers as a result of self-fertilization, inbreeding, or lack of adaptation or acclimatization. Since crossbred seed corn frequently yields less than one and sometimes less than either of the parent varieties, it would be very unwise to advise the general planting of crossbred seed without first demonstrating what varieties should be crossed in different localities to produce seed of higher yielding power than that of the best existing strains. The profits that may result from following

reliable methods and the losses that may result from following erroneous methods along these lines are tremendous because of the great extent to which corn is grown.

As acclimatization, crossbreeding, and selection have proved efficient in increasing the productiveness of corn, the question of practical importance is a determination of the best combination of these influencing factors. All these factors necessarily have a strong bearing upon the results presented in this paper. These results are presented here, however, with especial reference to the comparative productiveness of first-generation crosses and their parent varieties. In a future bulletin the results in these tests attributable to the effects of acclimatization and adaptation will be combined with results of other work and treated with especial reference to these factors and their influence upon yield.

TESTS IN MARYLAND.

WORK OF 1909.

CHOICE OF VARIETIES.

In order to make the tests of as much practical value as possible, varieties grown by successful corn growers in Maryland and adjoining States were chosen. Composite samples shelled from a hundred or more ears were used in order to equalize results of individual ear variations.

Detailed information regarding the history and description of these varieties is given in Table I, together with the germinating power of each lot of seed, both in the spring of 1909 and of 1910.

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TABLE I.—Varieties of corn and first-generation crosses used in Maryland tests.

Variety.	Parentage.	Adapted to climatic and soil conditions of—	Days to maturity.	Color and class.	Height of stalk (feet).		Germination (per cent). ¹	
					Pure variety.	First-generation cross.	Pure variety.	
							1908.	1910.
Selection:								
No. 119.....	Boone County White; a pure selection since 1880.....	(Washington, D. C., for 10 years.	120	White dent.....	9.26	10.00	100.0	98
No. 159.....	do.....	Auburn, Nebr., for 2 years..	120	do.....	9.00	9.00	98.0	94
No. 137.....	do.....	Central Texas, for 5 years..	120	do.....	9.50	9.75	97	98
No. 138.....	White and yellow strains mixed years ago.....	Murfreesboro, Tenn., for 10 years.	120	do.....	9.26	9.75	98.0	97
Whitcap.....	A pure selection since 1826.....	Wilmington, Del.	120	Mixed dent.....	9.26	9.00	96.5	98
Ohio Learning.....	Selection from Ohio Learning.....	Wilmington, Ohio, since 1826.	110	Yellow dent.....	8.26	8.25	99.5	99
Illrods Learning.....	A cross: pure bred since 1847.....	Chattanooga, Ill., for 25 years.	115	do.....	9.00	9.50	87.5	94
Raid Yellow Dent.....	An unstable cross of several years' selection.....	East Moline, Ill., since 1947.	115	do.....	8.75	9.00	98.5	96
Sturges Hybrid Flint.....	Pure selection since 1890.....	Farfield, Conn., for 20 years.	100	Yellow dent.....	7.00	8.50	98.0	100
Silvermine.....	Pure selection since 1871.....	Siberia, Ill., since 1871.....	110	White dent.....	8.75	9.25	98.5	95
Golden Eagle.....	A local strain of no particular breeding.....	Toulon, Ill., since 1871.....	110	Yellow dent.....	8.00	8.75	98.5	98
Fraser Yellow Dent.....	A cross: pure bred since 1890.....	Darwood, Md., for 15 years..	120	do.....	9.50	9.75	100.0	99
Selection 77.....	Somewhat variable type of Bloody Butcher.....	Philetus, Ohio, since 1880.....	120	White dent.....	9.50	9.26	94.0	92
Red Blase.....	{Cross of Dobson with Boone County White; pure bred since 1902.	Sullivan, Ind.....	120	Red dent.....	8.50	9.50	99.0	98
Cross:	{Cross of Hickory King with Boone County White; pure bred since 1902.	Washington, D. C., since 1902.	120	White dent.....	9.00	9.26	98.5	99
No. 190.....	A distinct and fairly pure-bred strain.....	Hickory, Va., since 1880.....	125	do.....	9.50	9.75	99.0	99
Hickory King.....	A pure selection of Clargue.....	Sabina, Ohio, for 12 years..	120	Yellow dent.....	10.00	10.00	98.0	96
Selection 78.....					9.50	9.75	99.0	99

¹ Of the two percentages of germination shown by means of braces in the 1910 column the lower one refers to seed of 1909; all other percentages of germination refer to original (1908) seed.

CROSSING THE VARIETIES.

Selection 119, which has been undergoing improvement for 10 years by the ear-to-row method of breeding and adaptation to conditions of the Potomac River soils near Washington, was chosen as the male parent, and the crossed seed was obtained by planting one of the other varieties in every third row in a field of this variety located 3 miles south of Washington, D. C., on a small tributary of the Potomac. As soon as the tassels appeared they were removed from all the varieties, so that no pollen matured in the field except on the rows of Selection 119, which fertilized the silks of all the other varieties, forming the supply of crossed seed, the productiveness of which was compared in 1910 with pure seed of the parents. About 30 of the best ears from these detasseled rows were chosen as seed for these tests. These ears were shelled, making a composite sample of each cross, which was used in planting all of the tests.

A supply of the original seed of all the varieties used in making these crosses was retained in the seed-corn room of the Department of Agriculture according to the best known methods of seed preservation.

GROWING PURE-BRED SEED FOR COMPARISON.

In order that the tests of productiveness might not be restricted to the old seed of the parent varieties, isolated plats of eight of the varieties, including the male parent—Selection 119—were grown in 1909 from the original seed. These 1909 plats were grown in the same localities and under the same conditions as the original seed.

WORK OF 1910.

LOCATION OF TESTS.

Duplicate tests of productiveness were made at Derwood and at Pike Crossing, Md. Derwood is located about 16 miles northwest of Washington, where the soil is of a red-clay, flint-stone nature, and the two tests were located on similar soil. Pike Crossing is situated about 5 miles north of Washington, where the soil is of a mica, red-clay nature. At Pike Crossing the two tests adjoined, but the first test was located on land that had been in sod for some 10 years or more, while the duplicate test was located on impoverished soil that had grown truck crops for fully as many years. At these points the season of 1910 was unusually dry and unfavorable for corn.

ORDER OF PLANTING THE TEST ROWS.

In order to have the means of comparing the productiveness of the crossed seed grown in 1909 with seed of the parents grown the same season and with the original seed of the parents used in making the crosses, the plantings were made in the order shown in Table II.

It will be seen that by this order the original or 1908 seed of the two parent varieties is planted on either side of the crossed seed, and that adjoining these two rows is a row from the seed of each parent grown in 1909. In all four of the tests the varieties were planted in the same relative order.

EQUALITY OF CONDITIONS FOR GROWTH AND PRODUCTIVENESS.

Care was taken to so locate the rows that those to be compared would have equal facilities for growth and productiveness. At each location and for each test rows of uniform width were marked off both ways. Five kernels were planted in each hill and the stand thinned to two stalks to the hill. Practically a perfect stand of plants was obtained for each row of each test. Each variety and first-generation cross was thus represented by the same number of plants, occupying the same number of square feet of adjacent, apparently similar, soil.

PRESENTATION OF RESULTS IN MARYLAND.

FIELD RECORDS IN DETAIL.

Table II presents full details of both the original and the duplicate test at Derwood and of like tests at Pike Crossing. The order of occurrence of the varieties in the table is the same as in the test plats.

TABLE II.—*Tests of parent varieties and first-generation crosses of corn.*

AT DERWOOD, MD.¹

Field row No.	Variety and cross.	First test.						Duplicate test.					
		Number of stalks.	Yield.					Number of stalks.	Yield.				
			Ears.	Increase over male parent.	Number of ears.		Stover.		Ears.	Increase over male parent.	Number of ears.		Stover.
					Good.	Poor.					Good.	Poor.	
			Lbs.	P. ct.			Lbs.		Lbs.	P. ct.			Lbs.
10	Selection 119, 1909.....	100	53	.....	35	45	52	100	70	.....	65	28	65
11	Selection 159, 1909.....	100	53	.....	40	51	47	98	66	.....	60	30	60
12	Selection 159, original.	100	64	.....	45	59	51	100	71	.....	60	36	61
13	Selection 159×Selection 119.....	100	56	— 3	20	71	61	102	71	1	60	41	60
14	Selection 119, original.	100	60	.....	40	56	61	99	66	.....	65	31	63
15	Selection 119, 1909.....	100	63	.....	50	45	59	100	71	.....	63	34	61
16	Selection 137, 1909.....	100	58	.....	35	56	67	98	60	.....	55	37	66
17	Selection 137, original.	97	56	.....	40	43	62	100	63	.....	60	37	61
18	Selection 137×Selection 119.....	101	67	8	40	60	67	100	75	6	65	33	72
19	Selection 119, original.	100	56	.....	45	43	62	98	64	.....	50	45	64
20	Selection 119, 1909.....	99	61	.....	35	57	59	100	70	.....	65	29	60
21	Selection 128, 1909.....	100	47	.....	26	59	71	100	51	.....	45	42	74
22	Selection 128, original.	100	47	.....	20	70	66	99	60	.....	50	45	68
23	Selection 128×Selection 119.....	100	58	— 9	50	54	74	100	68	0	60	38	69
24	Selection 119, original.	100	60	.....	30	62	61	99	55	.....	45	41	59
25	Selection 119, 1909.....	100	67	.....	57	39	57	100	66	.....	55	43	55

¹ Length of row 164 feet.

TABLE II.—*Test of parent varieties and first-generation crosses of corn*—Continued.

AT DEERWOOD, MD.—Continued.

Field row No.	Variety and cross.	First test.						Duplicate test.					
		Number of stalks.	Yield.				Number of stalks.	Yield.					
			Ears.	Increase over male parent.	Number of ears.			Stover.	Ears.	Increase over male parent.	Number of ears.		Stover.
					Good.	Poor.					Good.	Poor.	
			Lbs.	P. ct.			Lbs.		Lbs.	P. ct.			Lbs.
26	Selection 119×Selection 119.....	100	60	-10	60	64	51	101	66	-3	50	45	62
27	Selection 119, original.....	99	58	.....	20	74	54	100	70	.....	60	24	63
28	Whitecap, original.....	100	49	.....	35	63	49	100	53	.....	40	54	58
29	Whitecap × Selection 119.....	100	58	-13	30	70	55	100	72	6	60	29	72
30	Selection 119, original.....	100	54	.....	64	60	53	99	63	.....	55	39	55
31	Selection 119, 1909.....	100	66	.....	50	47	49	100	70	.....	60	36	56
32	Ohio Leaming, original.....	100	46	.....	26	63	27	100	50	.....	50	33	31
33	Ohio Leaming × Selection 119.....	100	56	-8	35	70	35	100	74	17	70	20	41
34	Selection 119, original.....	100	56	.....	32	65	53	97	69	.....	50	47	50
35	Selection 119, 1909.....	98	56	.....	25	64	53	100	56	.....	65	39	43
36	Illinois Leaming, original.....	100	46	.....	41	52	35	101	46	.....	50	38	34
37	Illinois Leaming×Selection 119.....	99	58	-1	59	55	47	100	55	-7	45	52	42
38	Selection 119, original.....	98	48	.....	35	63	52	100	54	.....	45	54	50
39	Selection 119, 1909.....	99	61	.....	46	48	58	100	62	.....	60	39	48
40	Reid Yellow Dent, original.....	99	50	.....	47	46	39	101	49	.....	56	29	29
41	Reid Yellow Dent×Selection 119.....	99	61	-6	45	56	50	99	60	3	60	43	49
42	Selection 119, original.....	99	50	.....	45	49	61	99	56	.....	50	52	57
43	Selection 119, 1909.....	101	69	.....	50	51	62	101	55	.....	55	39	44
44	Sturges Hybrid Flint, original.....	100	34	.....	22	76	33	106	30	.....	40	52	26
45	Sturges Hybrid Flint × Selection 119.....	100	58	-11	62	45	49	100	44	-11	40	56	35
46	Selection 119, original.....	99	60	.....	40	62	69	99	134	.....	20	60	37
47	Selection 119, 1909.....	100	62	.....	40	57	60	99	44	.....	30	64	45
48	Silvermine, original.....	100	50	.....	25	62	37	101	41	.....	33	43	34
49	Silvermine×Selection 119.....	100	57	-11	20	77	47	100	54	-4	47	40	44
50	Selection 119, 1909.....	98	66	.....	43	52	64	98	69	.....	50	47	56
51	Golden Eagle, original.....	100	43	.....	25	75	30	100	45	.....	48	41	36
52	Golden Eagle×Selection 119.....	98	60	-7	35	64	45	100	57	-10	45	55	44
53	Selection 119, 1909.....	100	63	.....	45	53	62	101	58	.....	52	43	49
54	Fraley Yellow Dent, original.....	100	59	.....	45	54	64	99	59	.....	55	45	54
55	Fraley Yellow Dent×Selection 119.....	98	59	0	43	63	56	100	60	0	50	40	68
56	Selection 119, 1909.....	100	55	.....	35	61	55	99	62	.....	54	42	49
57	Selection 77, 1909.....	100	53	.....	30	66	48	100	59	.....	55	45	58
58	Selection 77, original.....	100	43	.....	30	65	47	101	64	.....	55	42	53
59	Selection 77 × Selection 119.....	100	55	-5	25	70	48	97	58	-7	40	55	53
60	Selection 119, 1909.....	100	61	.....	40	45	57	100	63	.....	50	48	56
61	Red Blaze, original.....	97	46	.....	55	37	34	100	51	.....	70	28	28
62	Red Blaze×Selection 119.....	100	59	-9	43	52	45	98	65	5	65	36	50
63	Selection 119, 1909.....	100	69	.....	75	25	57	100	61	.....	50	48	51
64	Cross 100, 1909.....	99	53	.....	45	48	58	99	47	.....	60	43	55
65	Cross 100, original.....	100	44	.....	40	55	48	100	41	.....	40	45	48
66	Cross 100×Selection 119.....	100	51	-14	30	65	51	98	60	0	60	45	52
67	Selection 119, 1909.....	101	49	.....	35	61	48	100	59	.....	45	53	50
68	Cross 120, 1909.....	100	55	.....	50	46	49	100	63	.....	74	25	57
69	Cross 120, original.....	99	57	.....	37	60	49	99	61	.....	45	50	56
70	Cross 120×Selection 119.....	100	62	18	29	65	52	99	74	27	57	45	69
71	Selection 119, 1909.....	100	56	.....	40	60	52	98	58	.....	45	47	53
72	Hickory King, original.....	100	51	.....	55	51	78	100	60	.....	60	29	48

¹ Unreliable, as this row occupied the dead furrow.

TABLE II.—*Tests of parent varieties and first-generation crosses of corn—Continued.*

AT DEERWOOD, MD.—Continued.

Field row No.	Variety and cross.	First test.						Duplicate test.					
		Number of stalks.	Yield.					Number of stalks.	Yield.				
			Ears.	Increase over male parent.	Number of ears.		Stover.		Ears.	Increase over male parent.	Number of ears.		Stover.
					Good.	Poor.					Good.	Poor.	
73	Hickory King×Selection 119.....	101	Lbs. 63	P. ct. 7	52	50	Lbs. 79	100	Lbs. 74	P. ct. 21	77	24	Lbs. 53
74	Selection 119, 1909.....	100	62	.....	30	74	59	99	64	.....	43	47	59
75	Selection 78, 1909.....	100	55	.....	35	62	50	99	58	.....	54	41	51
76	Selection 78, original.....	99	58	.....	35	77	48	99	70	.....	60	37	55
77	Selection 78 × Selection 119.....	99	58	— 5	20	80	56	99	70	4	60	41	67
78	Selection 119, 1909.....	100	60	.....	38	64	60	99	70	.....	50	47	65

AT PIKE CROSSING, MD.¹

3	Selection 159, original.	By mistake this row was cut.						73	16	.....	5	46	35
4	Selection 159×Selection 119.....	82	40	—20	32	42	39	79	11	0	0	46	34
5	Selection 119, original.	80	48	.....	47	32	39	82	10	.....	0	39	35
6	Selection 119, 1909.....	79	50	.....	51	24	40	82	11	.....	0	50	37
7	Selection 137, original.	81	42	.....	32	36	40	79	5½	.....	0	27	31
8	Selection 137×Selection 119.....	82	50	2	47	32	46	76	6	—44	0	30	26
9	Selection 119, original.	78	44	.....	40	34	45	86	7½	.....	0	39	31
10	Selection 119, 1909.....	82	48	.....	48	30	42	82	10½	.....	1	51	32
11	Selection 138, original.	76	36	.....	29	38	48	80	4½	.....	0	24	32
12	Selection 138×Selection 119.....	85	55	16	54	27	61	82	5½	—49	0	25	43
13	Selection 119, original.	79	42	.....	36	35	48	80	7½	.....	0	33	33
14	Selection 119, 1909.....	86	47	.....	45	36	46	77	11	.....	0	48	34
15	Selection 119×Selection 119.....	80	44	—12	43	31	42	76	7	—45	0	33	35
16	Selection 119, original.	80	43	.....	39	37	43	79	8½	.....	1	38	36
17	Whitecap, original.....	80	39	.....	40	26	42	77	4	.....	0	21	29
18	Whitecap × Selection 119.....	84	48	— 4	43	33	40	81	5	—61	0	26	39
19	Selection 119, original.	85	47	.....	44	34	45	79	6½	.....	0	36	35
20	Selection 119, 1909.....	83	53	.....	47	32	50	82	14½	.....	1	51	37
21	Ohio Leaming, original.	81	36	.....	31	48	25	81	8	.....	1	43	21
22	Ohio Leaming×Selection 119.....	83	45	—16	48	29	34	80	9	—36	0	46	27
23	Selection 119, original.	80	54	.....	48	28	48	81	12½	.....	2	49	38
24	Selection 119, 1909.....	81	54	.....	50	29	50	80	13½	.....	0	54	37
25	Illinois Leaming, original.	78	43	.....	51	28	33	82	7	.....	0	41	30
26	Illinois Leaming×Selection 119.....	83	47	—12	52	22	50	82	8	—44	0	43	39
27	Selection 119, original.	79	52	.....	52	24	47	81	9½	.....	0	41	41
28	Selection 119, 1909.....	81	53	.....	52	24	57	79	15	.....	0	59	35
29	Reid Yellow Dent, original.	80	36	.....	38	36	32	78	6½	.....	0	38	26
30	Reid Yellow Dent × Selection 119.....	82	49	— 7	54	24	45	81	12½	—27	0	59	36
31	Selection 119, original.	82	51	.....	44	32	49	81	12½	.....	0	48	41
32	Selection 119, 1909.....	82	52	.....	47	28	54	81	20	.....	0	65	39
33	Sturges Hybrid Flint, original.	85	32	.....	44	33	27	81	7	.....	0	36	26
34	Sturges Hybrid Flint × Selection 119.....	82	49	— 1	56	20	41	82	19	—15	10	50	37
35	Selection 119, original.	82	49	.....	55	21	45	80	21	.....	2	54	46
36	Selection 119, 1909.....	83	47	.....	36	39	49	77	24½	.....	4	57	41
37	Silvermine, original.....	77	32	.....	20	52	46	78	14½	.....	0	55	24
38	Silvermine×Selection 119.....	86	40	—20	33	37	39	82	14½	—12	0	58	37
39	Selection 119, original.	79	50	.....	44	32	48	79	7	.....	0	32	46
40	Selection 119, 1909.....	82	53	.....	48	31	52	81	8½	.....	0	40	42

¹ Length of row 135 feet.

TABLE II.—*Tests of parent varieties and first-generation crosses of corn—Continued.*

AT PIKE CROSSING, MD.—Continued.

Field row No.	Variety and cross.	First test.						Duplicate test.					
		Number of stalks.	Yield.					Number of stalks.	Yield.				
			Ears.	Increase over male parent.	Number of ears.		Stover.		Ears.	Increase over male parent.	Number of ears.		Stover.
					Good.	Poor.					Good.	Poor.	
			Lbs.	P. ct.			Lbs.		Lbs.	P. ct.			Lbs.
41	Golden Eagle, original.	74	26	.....	20	46	25	81	24	.....	0	20	21
42	Golden Eagle×Selection 119	78	45	— 8	26	46	36	84	63	— 21	0	39	32
43	Selection 119, original.	74	45	.....	40	28	45	80	74	.....	0	34	43
44	Selection 119, 1909	78	45	.....	44	28	46	80	83	.....	0	39	46
45	Fraley Yellow Dent, original.	79	50	.....	48	27	53	82	5	.....	0	29	46
46	Fraley Yellow Dent×Selection 119	77	44	— 10	40	25	53	84	94	12	1	44	54
47	Selection 119, original.	79	50	.....	47	28	55	81	84	.....	0	44	49
48	Selection 119, 1909	77	53	.....	48	28	58	81	12	.....	0	58	51
49	Selection 77, original.	77	48	.....	40	32	50	82	64	.....	0	40	42
50	Selection 77 × Selection 119	71	46	— 13	41	21	48	82	8	— 20	0	44	48
51	Selection 119, original.	78	52	.....	40	34	56	81	8	.....	0	42	52
52	Selection 119, 1909	79	53	.....	44	29	59	82	84	.....	0	42	49
53	Red Blase, original.	79	44	.....	52	20	44	81	6	.....	0	37	29
54	Red Blase×Selection 119	78	48	— 9	52	18	45	81	74	— 20	0	42	44
55	Selection 119, original.	78	55	.....	48	24	54	82	104	.....	1	50	48
56	Selection 119, 1909	78	52	.....	52	16	58	82	124	.....	1	51	48
57	Cross 100, original.	80	40	.....	40	24	49	82	43	.....	2	16	44
58	Cross 100 × Selection 119	71	48	— 14	48	17	50	81	10	— 31	4	35	55
59	Selection 119, original.	72	52	.....	52	17	50	82	164	.....	4	45	80
60	Selection 119, 1909	82	60	.....	52	24	51	82	18	.....	5	45	57
61	Cross 120, original.	65	43	.....	38	24	48	81	174	.....	10	36	44
62	Cross 120 × Selection 119	77	58	12	60	12	57	82	204	22	10	42	56
63	Selection 119, original.	82	53	.....	45	38	47	82	154	.....	6	46	53
64	Selection 119, 1909	80	44	.....	36	37	51	80	17	.....	6	39	53
65	Hickory King, original.	68	35	.....	44	20	56	80	18	.....	12	45	47
66	Hickory King×Selection 119	75	49	10	58	14	51	83	174	6	6	40	54
67	Selection 119, original.	75	42	.....	28	37	51	80	164	.....	3	49	50
68	Selection 119, 1909	80	45	.....	36	40	48	80	124	.....	5	33	48
69	Selection 78, original.	77	33	.....	24	39	33	83	94	.....	0	34	36
70	Selection 78 × Selection 119	82	42	2	32	38	36	81	144	11	4	41	42
71	Selection 119, original.	80	37	.....	20	46	46	81	12	.....	1	41	45
72	Selection 119, 1909	81	37	.....	23	43	46	79	15	.....	6	39	41

1 1909 seed substituted for original seed.

Table II shows the usual inexplicable variations of test-plot work. Especially do such variations occur in the duplicate planting at Pike Crossing where the soil was so deplete of humus that from a financial standpoint the crop was a failure. Under these very adverse conditions it is rather surprising that the results accord with those of the other three tests as well as they do.

COMPARATIVE PRODUCTIVENESS OF SEEDS OF 1908 AND 1909.

Table II shows 42 instances in which the 1908 seed and 1909 seed of the male parent were planted in adjacent rows. In 33 of these 42 instances the 1909 seed produced the better, in five the 1908

seed produced the better, and in four the yield was the same. The 1908 seed produced 1,797 pounds of ears and the 1909 seed produced 1,938 pounds, a decreased yield of 7 per cent, due, perhaps, to the poor development or loss of vigor of the 1908 seed. The 1909 seed was grown from the 1908 seed under conditions that prevented any crossing with other varieties. Its greater productiveness therefore can not be attributed to mixture with other varieties.

While the 1908 seed of Selection 119 produced 7 per cent less than its progeny seed grown in 1909, it is not certain that the age of the 1908 seed was the cause of the decreased productiveness as the seed germinated perfectly the spring following its maturity, and also showed a germination of 98 per cent in the spring of 1910. The 1909 seed showed a germination of 100 per cent in the spring of 1910.

A comparison of the productiveness of the 1908 and 1909 seed of the female parents shows sufficient instances in which the 1908 seed produced better than the 1909 seed to make the average production of the 1908 seed equal to that of the 1909 seed.

CROSSES COMPARED IN PRODUCTIVENESS WITH THE MALE PARENT.

In computing the per cent of increased yield over the male parent in Table II the seed of the male parent grown the same year the crossing was accomplished is considered. As none of the female parents consistently produced better than the male parent, the male parent of all the crosses, Selection 119, is taken as the basis with which to compare the crosses. In all cases the average yield of two rows, the nearest one on either side of the cross, is compared with the cross.

Considering that contradictory results from any of the four tests is sufficient cause for ignoring all four of the tests, we have remaining five crosses which produced uniformly less than their male parent, and two comparisons in which the cross uniformly produced better than either parent.

The five first-generation crosses ($\times$ Selection 119) that uniformly produced less than the better of the two parents are Illinois Leaming, Sturges Hybrid Flint, Silvermine, Golden Eagle, and Selection 77.

The two first-generation crosses ($\times$ Selection 119) that uniformly produced better than either parent are Cross 120 and Hickory King.

COMBINED RESULTS OF THE FOUR MARYLAND TESTS.

In Table III the four separate Maryland tests are combined. In the Derwood test some of the female-parent varieties were represented by both 1908 and 1909 seed. In such instances the average of the two has been used. In these combined results this comparison of the crosses with the better yielding of the two parents is a straight comparison of the crosses with their male parent, for it is more pro-

ductive than any of the female parents except Fraley Yellow Dent, which it equals.

TABLE III.—*Productiveness of first-generation crosses of corn compared with that of the better parent, 1909 seed of the male parent being considered.*

Row No.	Variety and cross.	Number of stalks. ¹	Grain yield.		Stover yield.		Moisture in shelled grain when ears were weighed.	Water-free basis.	
			Ears.	Increase over better parent.	Weight.	Increase over heavier stover-producing parent.		Ears.	Increase over better parent.
			Pounds.	P. ct.	Pounds.	P. ct.	P. ct.	Pounds.	P. ct.
1	Selection 150 × Selection 119.	363	178	- 9	194	- 2	31.4	122.1	-12
3	Selection 119, 1909.....	361	195	.....	197	.....	28.8	138.8	.....
4	Selection 137.....	358	167	.....	200	.....	28.5	119.4	.....
5	Selection 137 × Selection 119.	359	198	3	211	6	30.0	138.6	1
7	Selection 119, 1909.....	363	190	.....	193	.....	28.8	135.3	.....
8	Selection 138.....	356	144	.....	220	.....	30.2	100.5	.....
9	Selection 138 × Selection 119.	367	187	- 2	247	12	31.9	127.4	- 6
11	Selection 119, 1909.....	363	191	.....	192	.....	28.8	136.0	.....
12	Selection 119 × Selection 119.	357	177	-10	190	- 1	28.8	126.1	-10
14	Whitcap, original.....	357	145	.....	178	.....	27.2	105.6	.....
15	Whitcap × Selection 119....	365	183	- 7	215	12	27.7	132.3	- 6
17	Selection 119, 1909.....	365	204	.....	192	.....	28.8	145.3	.....
18	Ohio Learning, original.....	362	140	.....	104	.....	22.1	109.1	.....
19	Ohio Learning × Selection 119.....	363	184	- 4	137	-27	22.2	142.1	5
21	Selection 119, 1909.....	359	180	.....	183	.....	28.8	128.2	.....
22	Illinois Learning, original.....	361	142	.....	132	.....	27.6	102.8	.....
23	Illinois Learning × Selection 119.....	364	168	- 9	178	- 7	26.7	123.1	- 7
25	Selection 119, 1909.....	359	191	.....	198	.....	28.8	136.0	.....
26	Reid Yellow Dent, original.....	358	142	.....	126	.....	24.8	106.7	.....
27	Reid Yellow Dent × Selection 119.....	361	183	- 5	180	- 9	26.3	134.8	- 2
29	Selection 119, 1909.....	365	196	.....	199	.....	28.8	139.6	.....
30	Sturges Hybrid Flint, original.....	372	103	.....	112	.....	19.9	82.5	.....
31	Sturges Hybrid Flint × Selection 119.....	364	170	- 9	162	-18	25.5	126.7	- 5
32	Selection 119, 1909.....	359	178	.....	195	.....	28.8	126.8	.....
33	Silvermine, original.....	351	138	.....	141	.....	23.8	105.2	.....
34	Silvermine × Selection 119..	368	166	-11	167	-18	27.6	120.2	-10
35	Selection 119, 1909.....	359	197	.....	214	.....	28.8	140.3	.....
36	Golden Eagle, original.....	355	117	.....	112	.....	25.6	87.0	.....
37	Golden Eagle × Selection 119.	360	169	- 9	157	-25	25.5	125.9	- 5
38	Selection 119, 1909.....	359	175	.....	203	.....	28.8	124.6	.....
39	Fraley Yellow Dent, original.....	360	173	.....	217	.....	27.2	125.9	.....
40	Fraley Yellow Dent × Selection 119.....	359	173	- 3	231	6	29.2	122.4	- 3
41	Selection 119, 1909.....	357	180	.....	212	.....	28.8	128.2	.....
42	Selection 77.....	360	168	.....	195	.....	30.7	116.4	.....
43	Selection 77 × Selection 119..	350	167	- 9	197	- 9	30.0	116.9	-10
44	Selection 119, 1909.....	361	186	.....	223	.....	28.8	132.5	.....
45	Red Blaze, original.....	357	147	.....	145	.....	26.0	108.8	.....
46	Red Blaze × Selection 119..	362	180	- 5	184	-16	27.4	130.7	- 3
47	Selection 119, 1909.....	355	193	.....	214	.....	28.8	137.4	.....
48	Cross 100.....	361	138	.....	198	.....	27.4	100.2	.....
49	Cross 100 × Selection 119..	350	169	-11	208	- 0.3	29.3	119.5	-11
50	Selection 119, 1909.....	365	185	.....	203	.....	28.8	131.7	.....
51	Cross 120.....	345	179	.....	198	.....	32.2	121.4	.....
52	Cross 120 × Selection 119..	358	215	20	234	14	29.2	152.2	19
53	Selection 119, 1909.....	359	174	.....	209	.....	28.8	123.9	.....
54	Hickory King, original.....	348	164	.....	265	.....	33.7	108.7	.....
55	Hickory King × Selection 119.....	359	204	13	267	1	32.0	138.7	8
56	Selection 119, 1909.....	359	186	.....	215	.....	28.8	132.5	.....
57	Selection 78.....	359	163	.....	171	.....	28.1	117.2	.....
58	Selection 78 × Selection 119..	361	184	0.3	201	- 6	29.8	129.3	- 1
59	Selection 119, 1909.....	360	181	.....	214	.....	28.8	128.9	.....

¹ Length of row 598 feet.

Eleven of the fourteen crosses of distinct varieties produced less grain than the better yielding of the two parents. When the pounds of ears harvested is reduced to a water-free basis, according to the percentage of water in the shelled grain at harvest time, the general results remain the same, namely, 11 comparisons in which the first-generation cross produced less and 3 in which it produced more than the better yielding of the two parents.

In Table IV those crosses which produced better than either parent are classed as advantageous. The others are classed as disadvantageous.

TABLE IV.—*First-generation crosses of corn (male parent, Selection 119), showing pounds of grain produced (water-free basis) and classified as advantageous and disadvantageous.*

Female parent and classification.	Yield.			
	Of parent.		Of cross.	Increase over better parent.
	Female.	Male.		
Disadvantageous—Crosses less productive than the better parent:	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Per cent.</i>
Whitcap.....	106	141	122	— 6
Illinois Leaming.....	103	132	123	— 7
Reid Yellow Dent.....	107	138	135	— 2
Sturges Hybrid Flint.....	83	133	127	— 5
Silvermine.....	105	134	120	—10
Golden Eagle.....	87	132	126	— 5
Fraley Yellow Dent.....	126	126	122	— 3
Selection 77.....	116	130	117	—10
Red Blaze.....	109	135	131	— 3
Cross 100.....	100	135	120	—11
Selection 78.....	117	131	120	— 1
Average.....	105	133	126	— 6
Advantageous—Crosses more productive than the better parent:				
Ohio Leaming.....	109	137	143	5
Cross 120.....	121	128	152	19
Hickory King.....	109	128	139	8
Average.....	113	131	145	10

ADVANTAGEOUS CROSSES.

Without consideration of water content the Ohio Leaming cross would be a disadvantageous cross, but the dryness of the ears, due doubtless in some degree to the earliness of the female parent, causes it to fall into the class of advantageous crosses with an increased yield of 5 per cent over Selection 119. A cross made in 1900 in which this strain of Leaming was used as male parent also produced dry and unusually solid ears.

Cross 120 was originated in 1902 by planting occasional rows of Hickory King in a field of Selection 119. All Hickory King stalks were detasseled. Since 1902 Cross 120 and Selection 119 have been improved in yield and adapted to climatic and soil conditions near Washington, D. C., by yearly growing ear-to-row breeding plats and saving seed from the best stalks of the highest yielding rows.

It is of especial interest that these two improved, acclimated, and related strains when crossed in 1909 should give a first-generation cross of much greater yielding power than either parent. This first-generation cross produced better than any of the other first-generation crosses and better than any of the other varieties tested. It is the only cross that produced far better than either parent in all four tests. By these tests the value of the seed of this particular first-generation cross for the conditions prevailing at these points in Maryland in 1910 has been demonstrated. These two strains are now being crossed extensively in producing seed for general planting. This cross-pollinated seed is designated "First-Generation Cross No. 182."

The third and last advantageous cross of the 14 crosses, as classified in Table IV, is the same cross that gave origin to Cross 120, which, after six years of selection and adaptation, produces somewhat less than the first-generation cross of the same parents made in 1909, after each parent has undergone six years of selection and adaptation. This fact indicates that it is more profitable to acclimate and improve the parents of an advantageous cross separately and cross them yearly to obtain seed than to cross them once and then rely upon the acclimatization and improvement of the cross. Furthermore, since Cross 120, after six years of improvement, when crossed with Selection 119 gives a first-generation cross of superior productiveness, it would seem that the recrossing of a cross sometimes gives better seed than the crossing of the original pure-bred varieties. The advantage may be due to adaptation, as one of the original parents, Hickory King, has not been adapted to conditions near Washington, D. C.

DISADVANTAGEOUS CROSSES.

The Whitecap variety is adapted to conditions in Delaware, where it is quite extensively grown. It yields a very large ear, with a large cob, and yellow kernels with white caps. Neither in weight of ears as harvested nor on a water-free basis did the first generation cross of Whitecap and Selection 119 produce as well as the male parent.

The Illinois Leaming, though a pure selection from the Ohio Leaming, is now very unlike it in appearance. The Illinois Leaming is of a rougher type, with broader kernels. According to pounds of ears at harvest the crosses of the two strains of Leaming with Selection 119 fell below the male parent in production. The Illinois Leaming cross did not produce as well as the Ohio Leaming cross, and the grain contained more water at harvest time. Making the comparison of yields on a water-free basis the Ohio Leaming cross is advantageous and the Illinois Leaming cross is disadvantageous.

Sturges Hybrid Flint, the only flint variety used in these experiments, is a large-eared yellow corn adapted to Connecticut conditions. It has stalks considerably shorter than those of the male parent and is 20 days earlier. The cross was intermediate between the two parents in size and time of maturity. The first-generation cross produced much better than the female parent, but not quite as well as the male parent.

Silvermine, a white dent, and Golden Eagle, a yellow dent, are the earliest varieties used in these experiments except Sturges Hybrid Flint. Their first-generation crosses with Selection 119 produced much better than the female parents, but not quite as well as the male parent. In comparison with the results from this same seed as tested in California (discussed later) it should be noted here that, while in Maryland Silvermine is but an average producer and Golden Eagle is second to the poorest of all the varieties, under California conditions both these varieties rank very high in production.

Fraley Yellow Dent is the variety that for 15 years has been grown on the Derwood farm on which two of these four tests were made. It is a productive variety adapted to the conditions at Derwood and unrelated to Selection 119. Among the 14 first-generation crosses tested this is the only instance in which both parents are more productive than the first-generation cross. The 1908 seed of the female parent produced slightly better than the cross. Except that Fraley Yellow Dent differs in color from the male parent and has not been improved by ear-to-row selection, the conditions of this disadvantageous cross are similar to those of the most advantageous cross of the series, both parents being well adapted to climatic and soil conditions and highly productive.

Selection 77 resembles Cross 120 and like it has undergone many years of selection. Cross 120 is adapted to Maryland conditions, and Selection 77 to Scioto River Valley conditions in Ohio. With Selection 119 as male parent Cross 120 makes a highly advantageous cross and Selection 77 a disadvantageous cross.

Cross 100 was made at the same time (1902) and in the same manner as Cross 120, Boone County White being the male parent in each case. Hickory King, a broad-kerneled small-cobbed corn, was female parent of Cross 120, and Dotson, a long-kerneled, small-eared, small-cobbed corn, was female parent of Cross 100. The two crosses have had similar ear-to-row selection since 1902. Cross 100 has yearly been grown on poorer soil than has Cross 120. Although of such similar history and treatment, when these crosses are crossed with the related variety, Boone County White, one

makes a highly advantageous first-generation cross and the other a disadvantageous first-generation cross.

Of all the varieties used as female parents, the most productive and the seven least productive formed disadvantageous first-generation crosses with Selection 119.

COMPARISON OF FIRST-GENERATION CROSSES WITH THE 1908 SEED OF BOTH
PARENTS.

Although placing the odds in favor of the crosses, a comparison is here made between the productiveness of first-generation crosses and that of the parents as grown from the original (1908) seed.

There are 31 instances in which the first-generation cross occupied a row between rows of either parent in which the 2-year-old seed was planted. In these 31 comparisons the cross exceeds the better of the two parents in 14, equals it in 1, and produces less in 16. Of these 16 cases the male parent exceeds the cross in 15 and the female parent (the Fraley Yellow Dent variety) once.

It should be noted here that if these Maryland tests had been restricted to the original seed of the parents, as has been done in a few reported tests of this nature, the first-generation crosses would have stood much higher in production in comparison with the parent varieties.

RELATIVE GRAIN PRODUCTION OF PARENT VARIETIES AND FIRST-GENERATION
CROSSES.

Expressed in terms of bushels per acre, allowing 70 pounds of ears containing 15 per cent of moisture to the bushel, the parents and crosses rank as follows for the four tests combined:

Male parent, 1909 seed.....	49
First-generation crosses, 1909 seed.....	47
Male parent, 1908 seed.....	45
Female parents, mostly 1908 seed.....	39

This relative production is shown in figure 1. As the yield for each field row shown in the diagram is the combined yield of a row from each of the four tests, the curves show the relative production of the different lots of seed with fluctuating variations and variations due to soil conditions somewhat reduced.

The four Maryland tests show the production of the crosses in general to be much above the average for the parents and somewhat below the male parent. Of the 14 crosses between distinct strains the cross of Cross 120 with Selection 119 is the only one that is remarkably superior to Selection 119 for the soil and climatic conditions under which the tests were conducted. The increased

productiveness of this cross seems sufficient to warrant the crossing of these two strains in producing seed for general use in Maryland and Virginia, where conditions similar to those of the tests exist.

As 1909 seed of the male parent occupied every third or fourth row in all four of the tests, a check or standard is afforded for comparing the productiveness of all the varieties and crosses. In Table V the varieties and first-generation crosses are classified and arranged in separate columns in the order of their productiveness, the most productive being mentioned first and ranked as 1. In computing the comparative productiveness of the varieties and crosses for this table the yield of a variety is decreased or increased proportionately

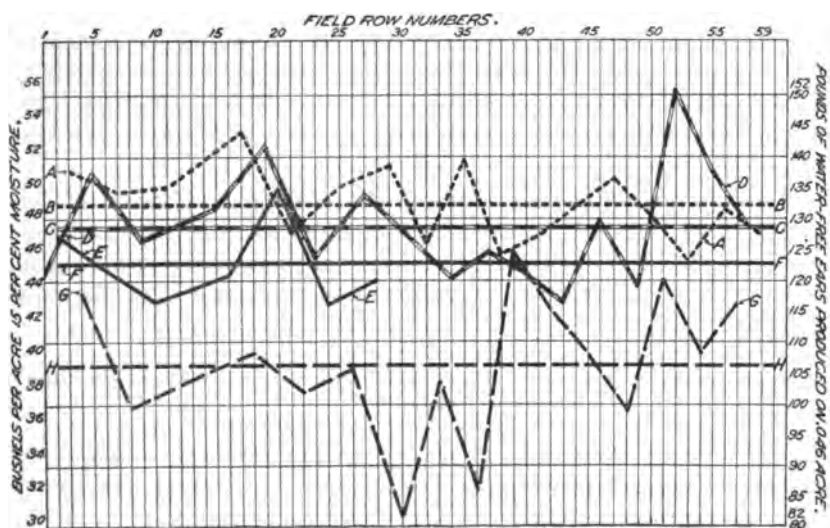


FIG. 1.—Diagram showing the relative production of parent varieties of corn and their first-generation crosses in Maryland, 1910: A, Male parent, variation of 1909 seed; B, male parent, mean of 1909 seed; C, mean of crosses; D, variation of crosses; E, male parent, variation of 1908 seed; F, male parent, mean of 1908 seed; G, variation of female parents; H, mean of female parents.

as the average yield of the two nearest rows of Selection 119 exceeds or falls short of the general average of Selection 119 for all rows in all the tests.

From the seven best female parents the crosses of six are found among the seven best crosses, Selection 77 being the only high-producing variety whose cross is a poor producer. Along with this indication that the productiveness of the parents influences the productiveness of the cross there are sufficient exceptions to indicate that the productiveness of a first-generation cross is sometimes determined to a great degree by other factors.

TABLE V.—*Parent varieties and crosses classified and ranked according to the computed production of ear corn (basis of 15 per cent moisture).*

Rank.	First-generation cross (× Selection 119).	Parent variety.	Yield per acre.
			<i>Bushels.</i>
1	Cross 120.....		58
2	Hickory King.....		53
3	Ohio Leaming.....		51
4		Selection 119 (average for 60 rows).....	49
5		Fraley Yellow Dent.....	48
6	Selection 78.....		48
7	Reid Yellow Dent.....		47
8	Fraley Yellow Dent.....		47
9	Red Blase.....		47
10	Sturges Hybrid Flint.....		46
11	Golden Eagle.....		46
12		Cross 120.....	46
13	Whitecap.....		46
14	Illinois Leaming.....		45
15	Silvermine.....		44
16	Selection 77.....		44
17		Selection 78.....	44
18		Selection 77.....	43
19	Cross 100.....		43
20		Hickory King.....	41
21		Red Blase.....	39
22		Ohio Leaming.....	39
23		Silvermine.....	38
24		Illinois Leaming.....	38
25		Reid Yellow Dent.....	38
26		Whitecap.....	36
27		Cross 100.....	36
28		Golden Eagle.....	32
29		Sturges Hybrid Flint.....	30

STOVER WEIGHTS OF PARENTS AND CROSSES COMPARED.

As no determinations were made of the water content of the stover, a comparison of weights of stover at harvest time does not represent food value and is of little importance except in indicating the earliness of maturity of the crosses and parent varieties. The stalks of the later maturing varieties contained considerable sap when weighed the latter part of October, while those of the earlier maturing varieties contained very little sap. In 4 cases out of the 14 the stover weight of the crosses is lighter than the average of the two parents. In 3 of these 4 cases the female parent matures fully 10 days earlier than Selection 119.

In general, the crosses seemed intermediate between the parents regarding height and time of maturing. It seems that the earlier maturing parents transmitted to their crosses their early-maturing character in sufficient degree to cause the stover to weigh less than the average for the two parents. Sturges Hybrid, the only flint variety in the test, is an exception in this respect. In no instance was the stover weight of a cross as light as that of the lighter producing parent.

The cross of Cross 120, which gave so remarkable an increase in grain production, also gave 14 per cent increased stover weight over

the heavier producing parent and 16 per cent increase over the average of its two parents. The Whitecap cross also gave 16 per cent increase over the average of its two parents and 12 per cent over the heavier producing parent, but in grain production it fell 6 per cent below the better of its two parents.

Of the 14 first-generation crosses of distinct varieties 10 produced fewer pounds of stover than the heavier yielding of the two parents.

CORN CROSSES AT CHICO, CAL., 1910.

CONDITIONS OF THE TEST.

The crosses made in 1909 in Maryland were also grown at Chico, Cal., in 1910, in comparison with their parent varieties. The plantings were so arranged that each row of the cross came between rows of its parent varieties.

The soil upon which these plantings were made was medium loam which had grown alfalfa for four years previous to 1910.

The land was broken to a depth of about 10 inches in December, 1909, with a second breaking in April, 1910, to a depth of 6 inches, and marked out in shallow furrows $3\frac{1}{2}$ feet apart. Both plowings were made in lands running north and south and the corn rows were marked out east and west, so that no rows would fall on dead or back furrows.

On April 14 three kernels were dropped by hand in each hill in the furrows and lightly covered with the foot. Hills were $3\frac{1}{2}$ feet apart in the row and 80 to each row. Four cultivations were given during the season.

On account of the surface soil being somewhat dry at planting time and some seed being taken by gophers, an uneven stand resulted.

The rainfall after planting amounted to less than one-half inch and no irrigation was given. Sufficient water was contained in the soil early in the season to give all varieties a good growth of stalk, the average height being about $8\frac{1}{2}$ feet. This moisture supply was not great enough, however, to produce a good crop of ears. Many of the ears were small and about 25 per cent of the stalks were barren.

The number of stalks per row, number of hills, average number of stalks per hill, pounds of ears per row, average number of pounds per stalk, percentage increase in yield per stalk of cross over the better parent, number of good and poor ears, and weight of stover are given in Table VI.

The order of plantings is preserved in the table, but for greater ease in comparing the cross with its parent varieties each row of Selection 119 is given twice.

The yield per stalk of the different varieties is represented graphically in diagram 1.

DIAGRAM 1.—*Variation in yield per stalk of crosses and parent varieties of corn at Chico, Cal., 1910.*¹

Field row No.	Variety and cross.	Pound.				
		0.0	0.1	0.2	0.3	0.4
1	Selection 119.....					
2	Illinois Leaming×119.....					
3	Illinois Leaming.....					
4	Selection 78.....					
5	Selection 78×119.....					
6	Selection 119.....					
7	Red Yellow Dent×119.....					
8	Red Yellow Dent.....					
9	Fraley Yellow Dent.....					
10	Fraley Yellow Dent×119.....					
11	Selection 119.....					
12	Silvermine×119.....					
13	Silvermine.....					
14	Selection 137.....					
15	Selection 137×119.....					
16	Selection 119.....					
17	Selection 138×119.....					
18	Selection 138.....					
19	Hickory King.....					
20	Hickory King×119.....					
21	Selection 119.....					
22	Golden Eagle×119.....					
23	Golden Eagle.....					
24	Whitecap.....					
25	Whitecap×119.....					
26	Selection 119.....					
27	Cross 100×119.....					
28	Cross 100.....					
29	Selection 150.....					
30	Selection 150×119.....					
31	Selection 119.....					
32	Ohio Leaming×119.....					
33	Ohio Leaming.....					
34	Sturges Hybrid Flint.....					
35	Sturges Hybrid Flint×119.....					
36	Selection 119.....					
37	Selection 77×119.....					
38	Selection 77.....					
39	Selection 119 (1908).....					
40	Selection 119 (1908)×119.....					
41	Selection 119.....					
42	Cross 120×119.....					
43	Cross 120.....					
44	Red Blaze.....					
45	Red Blaze×119.....					
46	Selection 119.....					

¹ The yield of first-generation crosses is indicated by the heavier lines.

TABLE VI.—*Tests of production of parent varieties and first-generation crosses of corn at Chico, Cal., 1910.*

Field row No.	Variety and cross.	Stalks.	Hills.	Stalks per hill.	Yield.							
					Weight of ears.			Number of ears.		Weight of stover.		
					In row.	Per stalk.	Increase per stalk over better parent.	Good.	Poor.	Per row.	Per stalk.	
					Lbs.	Lbs.	P. ct.			Lbs.	Lbs.	
1	Selection 119.....	169	72	2.4	41	0.242	.....	52	75	130	0.770	
2	Illinois Leaming×119.....	140	65	2.1	37	.264	4	48	68	106	.757	
3	Illinois Leaming.....	111	60	2.2	28	.254	.....	40	48	69	.622	
4	Selection 78.....	131	52	2.5	31	.247	.....	48	42	83	.633	
5	Selection 78×119.....	142	61	2.3	35	.248	0	52	57	106	.747	
6	Selection 119.....	155	71	2.2	35	.226	.....	40	68	137	.884	
7	Selection 119.....	155	71	2.2	35	.226	.....	40	68	137	.884	
8	Reid Yellow Dent×119.....	122	56	2.2	34	.278	-1	52	44	85	.697	
9	Reid Yellow Dent.....	146	68	2.1	41	.281	.....	57	51	97	.666	
10	Fraley Yellow Dent.....	142	67	2.1	27	.190	.....	38	58	118	.832	
11	Fraley Yellow Dent×119.....	149	70	2.3	32	.215	0	40	60	133	.894	
12	Selection 119.....	159	68	2.4	34	.214	.....	36	75	121	.761	
13	Selection 119.....	159	68	2.4	34	.214	.....	36	75	121	.761	
14	Silvermine×119.....	160	68	2.3	51	.318	-17	65	66	123	.769	
15	Silvermine.....	107	60	1.8	41	.363	.....	55	54	70	.654	
16	Selection 137.....	106	60	1.8	31	.287	.....	42	58	99	.916	
17	Selection 137×119.....	148	64	2.3	47	.331	15	60	60	134	.906	
18	Selection 119.....	147	63	2.3	39	.265	.....	57	68	117	.796	
19	Selection 119.....	147	63	2.3	39	.265	.....	57	68	117	.796	
20	Selection 138×119.....	141	67	2.1	50	.355	4	62	72	156	1.106	
21	Selection 138.....	146	69	2.1	50	.342	.....	68	70	135	.925	
22	Hickory King.....	122	59	2.1	27	.221	.....	56	62	106	.870	
23	Hickory King×119.....	129	60	2.1	39	.303	-15	72	52	122	.946	
24	Selection 119.....	163	70	2.3	58	.356	.....	74	80	132	.810	
25	Selection 119.....	163	70	2.3	58	.356	.....	74	80	132	.810	
26	Golden Eagle×119.....	144	66	2.2	64	.445	16	92	47	120	.834	
27	Golden Eagle.....	122	58	2.1	47	.385	.....	72	42	75	.615	
28	Whitecap.....	109	50	2.2	26	.238	.....	35	52	110	1.010	
29	Whitecap×119.....	116	59	2.0	37	.319	8	44	56	129	1.113	
30	Selection 119.....	126	53	2.4	37	.294	.....	37	69	110	.872	
31	Selection 119.....	126	53	2.4	37	.294	.....	37	69	110	.872	
32	Selection 119.....	126	53	2.4	37	.294	.....	37	69	110	.872	
33	Selection 119.....	126	53	2.4	37	.294	.....	37	69	110	.872	
34	Selection 119.....	126	53	2.4	37	.294	.....	37	69	110	.872	
35	Cross 100×119.....	123	61	2.0	40	.325	11	55	60	113	.918	
36	Cross 100.....	121	58	2.1	21	.173	.....	52	63	101	.834	
37	Selection 159.....	99	53	1.9	26	.263	.....	34	54	85	.859	
38	Selection 159×119.....	107	54	2.0	31	.290	-11	40	57	104	.972	
39	Selection 119.....	115	52	2.2	37½	.326	.....	46	57	111	.965	
40	Selection 119.....	115	52	2.2	37½	.326	.....	46	57	111	.965	
41	Ohio Leaming×119.....	114	53	2.1	37	.324	-15	50	62	92	.806	
42	Ohio Leaming.....	102	54	1.9	39	.382	.....	64	40	60	.587	
43	Sturges Hybrid Flint.....	79	49	1.6	19	.241	.....	40	40	67	.849	
44	Sturges Hybrid Flint×119.....	106	50	2.1	35	.330	-11	52	60	106	1.000	
45	Selection 119.....	80	41	2.0	29½	.369	.....	42	40	77	.961	
46	Selection 119.....	80	41	2.0	29½	.369	.....	42	40	77	.961	
47	Selection 77×119.....	95	44	2.2	30½	.399	0	36	52	90	.946	
48	Selection 77.....	71	35	2.0	27	.380	.....	44	32	70	.986	
49	Selection 119 (1908).....	95	45	2.1	23½	.248	.....	26	63	93	.930	
50	Selection 119×119.....	83	50	1.7	31	.373	20	32	63	94	1.130	
51	Selection 119.....	96	46	2.1	29½	.310	.....	36	52	93	.930	
52	Selection 119.....	95	46	2.1	29½	.310	.....	36	52	93	.930	
53	Cross 120×119.....	111	59	1.9	41	.373	12	45	68	125	1.135	
54	Cross 120.....	75	39	1.9	25	.334	.....	43	37	67	.893	
55	Red Blase.....	67	37	1.8	22	.328	.....	38	38	54	.806	
56	Red Blase×119.....	111	57	1.9	43½	.395	20	64	54	97	.875	
57	Selection 119.....	89	44	2.0	22	.247	.....	26	58	80	.900	

COMPARISON OF CROSSES WITH PARENT VARIETIES.

It has been claimed, though not universally accepted, that first-generation corn crosses are superior in producing power to the varieties crossed. The data herein submitted seem to bear out such a conclusion when the majority of cases and the average of all are considered.

Of the 18 crosses included in this test, only 2 do not exceed in yield the average of the two varieties crossed. The average yield per stalk of the 10 plantings of Selection 119 is 0.280 pound; for the 18 varieties used as female parents, 0.284 pound; and for the crosses, 0.320 pound; an increase of 0.038 pound per stalk in favor of the average of the crosses.

There is no special advantage in growing first-generation crosses unless such crosses can be depended upon to yield consistently and constantly more than either of the varieties used in making the cross. This gain must be sufficiently large to insure compensation for the rather careful work necessary in making the cross and in keeping pure two varieties of corn for this purpose.

Of the 18 crosses in this test, 9 exceed either parent in the yield per stalk, and 9 are equaled or exceeded by one or the other of the parents. The difference in the yields of the better parent and of the cross ranges in amount from 4 to 20 per cent in the 9 comparisons in which the crosses exceed, and from zero to 17 per cent in the 9 in which the better parent exceeds the cross.

Not only are there the same number of comparisons in which the cross exceeds and fails to exceed the better parent, but the average yield per stalk of the crosses and that of the better parents is the same, being 0.320 pound in each case.

These data do not show that first-generation crosses can, in the greater number of cases, be depended upon to produce more than the better of the two varieties crossed.

Two additional crosses were grown in the test at Chico. The male parent used was Selection 160, a large yellow flint. This corn has been grown in California for 12 years or more and at Chico for 5 years. It seems to be well acclimated and has proved to be the best yielder of a number of varieties grown at Chico in the last 3 years.

The two varieties used as female parents were Ohio Leaming and Silvermine. Next to Selection 160 these have been the highest yielding of the varieties tested at Chico.

The crosses were made by hand-pollinating ears of these two varieties with pollen from Selection 160 in the varietal test rows at Chico in 1909. Several ears in each variety were also pollinated with pollen from different stalks of the same variety. In this way seed of the cross and that of the female parent used in the experiment

in 1910 was grown under identical conditions in 1909. The Selection 160 seed was also taken from the 1909 crop and from detasseled stalks in a near-by, though sufficiently isolated, field.

These two crosses are compared with their parent varieties in Table VII.

TABLE VII.—*Relative productiveness of first-generation crosses and parent varieties of corn crosses made and tested at Chico, Cal.*

Row No.	Variety and cross.	Stalks.	Hills.	Stalks per hill.	Yield.				
					Weight of ears.			Number of ears.	
					In row.	Per stalk.	De-crease per stalk under better parent.	Good.	Poor.
					Pounds.	Pounds.	P. ct.		
47	Silvermine.....	149	65	2.3	54	0.362		72	52
48	Silvermine × Selection 160.....	139	61	2.1	53	.382	10	88	46
49	Selection 160.....	140	64	2.2	50.5	.425		112	44
49	Selection 160.....	140	64	2.2	50.5	.425		112	44
50	Ohio Leaming × Selection 160.....	152	63	2.4	60.5	.398	9	111	61
51	Ohio Leaming.....	144	67	2.1	42	.282		58	50

RELATION OF ADAPTATION AND YIELD OF PARENT VARIETIES TO THE BEHAVIOR OF THE CROSSES.

Since there is a wide range of variability in the behavior of crosses between different varieties, it is of importance to discover, if possible, whether these differences have any relation to the yielding power of the parent varieties.

In this test, as is usual in a series of varieties collected from different localities and subjected to adverse conditions, a wide difference exists in the response of the different varieties to these conditions. Since all of the varieties are well selected and improved for the localities from which they came, the yield of each may be taken as an indication of its adaptation to the conditions of the test.

The highest yielding crosses (× Selection 119), arranged according to productiveness, are: Golden Eagle, Red Blaze, Cross 120, Selection 77, and Selection 138. A comparison of the yields of the original varieties shows that the female parents of these crosses rank in productiveness as follows: Golden Eagle, first; Red Blaze, seventh; Cross 120, sixth; Selection 77, fourth; Selection 138, fifth. The fact that the female parents of these high-yielding crosses rank high in yield among the original varieties is an indication that the adaptation and productivity of the parent variety determine the adaptation and productivity of the cross to some extent; or, in general, the highest yielding crosses may be expected to result from crossing the

highest yielding varieties. This view is supported by the results of a test of the same varieties and crosses in Maryland and also by the results obtained from the two crosses with Selection 160.

While this influence apparently exists, it is not sufficiently constant to be relied upon, as is shown by comparing the crosses Silvermine $\times$ Selection 119 and Ohio Leaming $\times$ Selection 119. The female parents of these crosses rank second and third in yield among the original varieties; the crosses are surpassed in productiveness by the crosses Sturges Hybrid Flint $\times$ Selection 119 and Cross 100 $\times$ Selection 119, the female parents of which rank low in yield.

The four best producers of the original varieties are Golden Eagle, Silvermine, Ohio Leaming, and Selection 77. The crosses of these four varieties with Selection 119 are distributed in the following manner as regards the degree of benefit from crossing: One case in which the cross shows a decided increase over the better parent, one in which the cross is intermediate between the two parents, and two in which the cross about equals the poorer parent.

The five poorest producing varieties are Cross 100, Fraley Yellow Dent, Hickory King, Whitecap, and Sturges Hybrid Flint. The crosses of these five varieties with Selection 119 are distributed as follows as regards benefit from crossing: Three better than the better parent, and two intermediate between the two parents.

The crosses with Selection 119 that show the greatest gain in yield over the better of their two parents are those of Red Blaze, Golden Eagle, Selection 137, and Cross 120. If yields of the original varieties and of the crosses are both considered, the female parents of these high-yielding crosses may be classed as one good and three intermediate in respect to yield.

From the examples set forth in the preceding paragraphs it would seem that no constant relation exists between the productivity of varieties and the increase or decrease in yield of their crosses as compared with the parent varieties. The lack of constancy in this relation may be seen in the following crosses: Ohio Leaming $\times$ Selection 119 produces less than either parent, although both are high-yielding varieties that have been pure bred for many years; the cross of Red Blaze (a high-yielding and well-selected variety) $\times$ Selection 119 gives an increase in yield of 20 per cent over the better parent; the cross of Cross 100, the lowest yielding variety in the test, with Selection 119 gives an increase in yield of 11 per cent over the better parent and practically equals in yield that of Ohio Leaming $\times$ Selection 119 (ranking eighth in yield among the crosses); while Fraley Yellow Dent, the next lowest yielding variety, crossed with Selection 119 is the lowest yielding cross in the test and is exceeded by all the varieties except Cross 100 and Fraley Yellow Dent.

These results show that some varieties combine or "nick" well, when crossed, forming crosses that are superior in yielding power to either parent, while other varieties do not combine well and the crosses are either less productive than the better parent or inferior to both parents. The factors that determine what the productiveness of the cross will be are not known, and apparently no external characters are discernible by which we can judge of their presence or absence. It is important, therefore, that crosses of varieties should be tried experimentally to ascertain their productiveness before growing them commercially or before making a general agricultural application of this method of corn breeding.

It is worthy of note that the crosses which produced best under the somewhat adverse conditions at Chico are not from the same combinations as those which produced best under conditions of normal rainfall in Maryland.

Table VII shows a comparison between an acclimated, well-adapted variety, the crosses of this with two varieties of later introduction, and these two varieties themselves.

In each of these comparisons the cross is intermediate in yield per stalk between the two varieties crossed. In other words, nothing was gained in yield by crossing an adapted, well-acclimated variety with a variety of later introduction, even though this variety is also a good yielder.

TESTS IN TEXAS.

WORK OF 1909.

Seed of a number of pure-bred varieties of corn was obtained early in 1909 for use in crossbreeding experiments in Texas. A list of these varieties and a brief description is given in Table VIII. The varieties were planted at Waco, Tex., early in March, 1909, one row of each of the other varieties alternating with two rows of Chisholm (the variety chosen to be the male parent). Tassels were removed from the stalks of all varieties except the Chisholm before any pollen had been shed. The crosses made in this manner, each having the same male parent but a different female parent, were planted in 1910 at Sherman, at Waco, and at Corsicana.

TABLE VIII.—Varieties of corn and first-generation crosses used in Texas tests.

Variety.	Parentage.	Region of growth.	Days to mature.	Color and class.	Height of stalk (feet). ¹	
					Pure variety.	First-generation cross.
Huffman.	Pure selection since 1881.	Central Tennessee for 60 years.	140	White dent.	8-8½	7-7½
Selection 136.	Laguna, from Mexico.	Central Texas for 7 years.	125-130	do.	7½-8	6-8
Selection 137.	Boone County White.	Central Texas for 5 years.	110-115	do.	6½	6½
Singaton.	A selection from a strawberry type of corn.	Northern Texas for 30 years.	120	Striped dent.	7½-8	7-7½
McCullough.	A cross of two yellow varieties made in 1901.	Northern Texas a number of years.	120	Yellow dent.	7	7
Graham Yellow.	Believed to have originated from a Kansas variety.	Central Texas for 5 years or longer.	120	do.	6	6-6½
Dan Patch.	Native strain in South Texas, probably mixed with Mexican varieties.	South-central Texas 25 years or longer.	110	White dent.	6½	6-7
Blow.	A local native variety in Anderson County.	Eastern Texas for 24 years.	120	do.	6½-7	6½-7
Lily of the Valley.	Chisholm.	Northern Texas a number of years.	120	do.	6½-7	6½-7
Schleberle.	A cross between a white dent variety and Gourd Seed.	Southern Texas for 20 years.	125-130	do.	7½-8	6½-7
Munson.	Taken from Georgia to Texas previous to 1905.	Central and northern Texas 5 years or longer.	125-130	do.	6-7	7
Gourd Seed.	Native unselected variety.	South-central Texas about 30 years.	120	do.	7-7½	6½-7
Bergeson Yellow.	South American and Mississippi varieties crossed in 1878 in Mississippi.	Northern Texas.	120	Yellow dent.	7	6-7
Moby Frollie.	Native strain in southern Texas grown under various names; probably at some time mixed with Mexican varieties.	Southern and northern Texas 5 years.	120	White dent.	6-7	6-7
Surecopper.	A red-cob white dent—well known in northern Texas.	South-central Texas 25 years or longer; northern Texas 4 years.	110	do.	6-7	6½
Chisholm.		Northern Texas about 30 years.	120	do.	6	.....

¹ As grown at Waco.

WORK OF 1910.

TEST AT SHERMAN, TEX.

The test at Sherman was located upon fertile black upland of uniform appearance. All the land used had been cropped the same the previous year, had been broken deep, and was in good condition when the corn was planted.

The planting was made in hills $3\frac{1}{2}$ feet apart each way; the crop was cultivated frequently, and the ground kept free of grass and weeds. The season at Sherman was extremely dry and the yields were very light.

The order in which the varieties and crosses were planted and their field-row numbers are shown in Table IX. Because of lack of uniformity in number of stalks per row of the different varieties, the comparisons have been made on the basis of production per stalk rather than on row yields. This method is followed in all cases.

The comparison is made between the yield of the cross and the higher yielding of the two parents. For practical purposes the cross can not be regarded as an improvement upon existing conditions or as worthy of propagation unless it is superior to the better parent. Where the comparison is between the cross and male parent the average of the two rows of the male parent nearest the cross has been used. This was also done in the test at Waco and Corsicana. The seed of the female parents used in the experiment is in every case taken from the 1908 crop, that is, from the same lot of seed that was used for the beginning of the experiment in 1909. The seed of the crosses is from the 1909 crop. The seed of Chisholm (the male parent) is in part from the 1908 crop, but mostly from the 1909 crop, entirely so at Sherman and Corsicana, and also in the greater part of the Waco test.

When the crop was harvested, determinations showed the percentage of moisture to be approximately the same for the different varieties. Taking into consideration the unavoidable percentage of error, it was believed that nothing would be gained by calculating the yields to a water-free basis. In computing the production per stalk only the main stalks were considered, as the suckers were not productive at any of the three places.

TABLE IX.—*Comparative productiveness of parent varieties of corn and first-generation crosses at Sherman, Tex., in 1910.*

[Area of each row one-seventieth of an acre.]

Row No.	Variety and cross.	Main stalks per row.	Suck-ers per row.	Yield of ears (husked).			Number of ears.	
				Per row.	Per stalk.	In-crease over better parent.	Good.	Poor.
				<i>Pounds.</i>	<i>Pounds.</i>	<i>Per ct.</i>		
2	Chisholm.....	76	3	91	0.125		3	37
3	Huffman × Chisholm.....	101	17	9	.069	-28	2	40
4	Huffman.....	105	39	3	.029		0	16
5	Chisholm.....	81	4	10	.123		4	39
6	Schleberle × Chisholm.....	107	7	91	.069	-32	0	41
7	Schleberle.....	101	5	111	.114		0	49
8	Chisholm.....	84	6	111	.140		5	44
9	Munson × Chisholm.....	100	19	12	.120	-21	3	49
10	Munson.....	97	21	9	.093		0	43
11	Chisholm.....	79	1	13	.165		6	45
12	Gourd Seed × Chisholm.....	96	13	17	.177	16	5	68
13	Gourd Seed.....	96	4	14	.143		0	57
14	Chisholm.....	89	0	121	.140		6	39
15	Lily of the Valley × Chisholm.....	100	7	181	.182	5	6	57
16	Lily of the Valley.....	95	6	161	.174		8	56
17	Chisholm.....	78	2	121	.160		4	43
18	Blow × Chisholm.....	101	27	141	.144	-17	2	61
19	Blow.....	101	11	9	.069		0	49
20	Chisholm.....	84	3	151	.184		2	57
21	Selection 136 × Chisholm.....	100	9	191	.195	23	6	66
22	Selection 136.....	101	13	16	.158		3	72
23	Chisholm.....	81	8	101	.130		0	48
24	Scarceropper × Chisholm.....	106	3	231	.219	-8	5	79
25	Scarceropper.....	100	6	231	.238		8	80
26	Chisholm.....	94	8	12	.128		1	47
27	Dan Patch × Chisholm.....	93	8	23	.247	13	3	83
28	Dan Patch.....	94	5	201	.218		5	74
29	Chisholm.....	89	7	12	.135		4	45
30	Selection 137 × Chisholm.....	102	22	171	.172	-6	4	71
31	Selection 137.....	92	6	161	.182		4	62
32	Chisholm.....	81	8	14	.173		2	51
35	Mosby Prolific × Chisholm.....	103	15	12	.117	-33	2	58
36	Mosby Prolific.....	92	35	8	.087		0	61
37	Chisholm.....	101	10	18	.178		6	62
38	Gorham Yellow × Chisholm.....	103	17	141	.141	-8	5	53
39	Gorham Yellow.....	96	13	111	.120		1	56
40	Chisholm.....	101	14	13	.129		4	53
41	Ferguson Yellow × Chisholm.....	101	10	121	.124	-15	1	69
42	Ferguson Yellow.....	98	13	131	.138		3	65
43	Chisholm.....	95	6	151	.163		3	68
44	McCullough × Chisholm.....	98	3	15	.153	-2	4	56
45	McCullough.....	100	10	13	.130		2	63
46	Chisholm.....	100	10	15	.150		0	70
47	Singleton × Chisholm.....	96	12	111	.122	-22	0	59
48	Singleton.....	98	6	11	.112		0	52

In 11 out of 15 comparisons the cross ranges from 2 to 33 per cent lower in yield than the better parent; in the remaining four comparisons the cross outyields the better parent by 5 to 23 per cent.

TEST AT WACO, TEX.

At Waco the test was located on deep Brazos Valley sand and the corn was drilled in rows $3\frac{1}{2}$ feet apart. A late frost killed some of the plants and so interfered to some extent with the uniformity of the stand. For this reason the comparisons of yields, as in the test at Sherman, have been made on the basis of production per stalk. The stands of three of the crosses were so uneven and irregular

that the comparisons could not be regarded as of value, and accordingly have not been considered in the results. The order of planting the varieties and crosses and their field-row numbers are shown in Table X.

TABLE X.—*Comparative productiveness of parent varieties of corn and first-generation crosses at Waco, Tex., in 1910.*

[Area of each row one-seventieth of an acre.]

Row No.	Variety and cross.	Main stalks per row.	Suckers per row.	Yield of ears (husked).			Number of ears.	
				Per row.	Per stalk.	Increase over better parent.	Good.	Poor.
				Pounds.	Pounds.	Per ct.		
4	Chisholm	46	0	19	0.413		19	21
5	Schieberle × Chisholm	54	0	30½	.565	7	31	24
6	Schieberle	38	0	20	.526		20	14
7	Chisholm	37	0	14	.378		11	26
8	Singleton × Chisholm	53	0	26½	.500		34	16
9	Singleton	37	0	15	.486	3	14	22
10	Chisholm	53	0	20	.377		20	27
11	McCullough × Chisholm	49	0	24	.490	29	30	20
12	McCullough	48	0	15	.312		13	30
13	Chisholm	54	0	20½	.380		19	30
14	Ferguson Yellow × Chisholm	60	0	32	.533	21	38	23
15	Ferguson Yellow	50	0	22	.440		15	34
16	Chisholm	65	0	29	.446		23	38
17	Gorham Yellow × Chisholm	51	0	26	.510	23	21	32
18	Gorham Yellow	34	0	12	.353		10	19
26	Selection 137	40	0	12	.300		4	30
27	Selection 137 × Chisholm	55	0	20	.364	-18	21	32
28	Chisholm	55	0	24	.436		30	20
29	Selection 136	65	0	34	.523		38	30
30	Selection 136 × Chisholm	75	0	43	.573	10	45	30
31	Chisholm	38	0	17	.447		12	27
32	Surcropper	51	0	21	.412		20	33
33	Surcropper × Chisholm	46	0	20	.435	3	23	23
34	Chisholm	35	0	14	.400		14	18
38	Blow	51	0	19	.373		15	34
39	Blow × Chisholm	63	0	28½	.452	4	25	41
40	Chisholm	48	0	22	.458		22	26
41	Gourd Seed	66	2	38½	.583		40	25
42	Gourd Seed × Chisholm	68	0	42½	.625	7	56	15
43	Chisholm	35	0	14	.400		10	23
44	Munson	45	0	25	.556		26	21
45	Munson × Chisholm	52	0	30	.577	4	30	25
46	Chisholm	49	0	23	.469		22	24
47	Mosby Prolific	44	3	16	.364		24	24
48	Mosby Prolific × Chisholm	53	5	23	.434	-9	42	13
49	Chisholm	41	0	20	.488		16	32

In 10 of the 12 comparisons the cross outyields the better parent, the increase ranging from 3 to 29 per cent; in the remaining 2 comparisons the cross yields 18 and 9 per cent less than the better parent.

TEST AT CORSICANA, TEX.

At Corsicana the test was located on sandy loam of medium fertility. The corn was planted in hills 3½ feet apart each way, cultivated well, and kept free of grass and weeds. The planting was made in a different manner from that at Sherman and at Waco, a smaller number of rows of Chisholm were planted and these were

arranged so that two of the crosses were planted adjacent to the same row of Chisholm. One of the crosses (Schieberle×Chisholm) was cut by mistake when green and fed to stock. The order of planting the varieties and crosses, and their field-row numbers, together with the results of the test, are shown in Table XI.

TABLE XI.—*Comparative productiveness of parent varieties of corn and first-generation crosses at Corsicana, Tex., in 1910.*

[Area of each row one eighty-sixth of an acre.]

Row No.	Variety and cross.	Main stalks per row.	Suckers per row.	Yield of ears (husked).			Number of ears.	
				Per row.	Per stalk.	Increase over better parent.	Good.	Poor.
				<i>Pounds.</i>	<i>Pounds.</i>	<i>Per ct.</i>		
7	Singleton.....	74	6	231	0.317	.....	24	32
8	Singleton×Chisholm.....	76	2	241	.322	2	27	37
9	Chisholm.....	70	4	204	.293	.....	28	28
10	McCullough×Chisholm.....	78	0	27	.346	11	32	30
11	McCullough.....	75	2	234	.313	.....	30	33
12	Ferguson Yellow.....	83	0	341	.416	.....	40	35
13	Ferguson Yellow×Chisholm.....	83	0	32	.386	— 7	40	30
14	Chisholm.....	84	4	261	.315	.....	30	33
15	Gorham Yellow×Chisholm.....	77	0	301	.396	21	40	31
16	Gorham Yellow.....	69	0	22	.319	.....	20	40
17	Selection 136.....	83	0	35	.422	.....	48	28
18	Selection 136×Chisholm.....	80	5	35	.437	4	40	36
19	Chisholm.....	65	0	22	.338	.....	23	30
20	Surcropper×Chisholm.....	87	3	354	.408	— 2	40	40
21	Surcropper.....	79	0	33	.418	.....	36	43
22	Dan Patch.....	78	2	34	.436	.....	44	28
23	Dan Patch×Chisholm.....	84	12	39	.464	6	38	47
24	Chisholm.....	85	3	30	.353	.....	35	38
25	Blow×Chisholm.....	95	5	344	.363	— 2	36	48
26	Blow.....	77	3	25	.325	.....	26	40
27	Lily of the Valley.....	75	2	301	.407	.....	26	34
28	Lily of the Valley×Chisholm.....	74	0	394	.534	31	51	26
29	Chisholm.....	67	5	26	.388	.....	28	30
30	Gourd Seed×Chisholm.....	78	7	344	.442	7	40	36
31	Gourd Seed.....	76	0	314	.414	.....	28	41
32	Munson.....	77	3	254	.331	.....	28	40
33	Munson×Chisholm.....	84	4	304	.363	— 2	32	43
34	Chisholm.....	76	0	27	.355	.....	35	30
35	Mosby Prolific×Chisholm.....	85	8	34	.400	6	52	27
36	Mosby Prolific.....	81	11	274	.340	.....	52	30
37	Selection 137.....	68	0	25	.368	.....	30	28
38	Selection 137×Chisholm.....	77	0	284	.370	— 2	32	36
39	Chisholm.....	75	3	30	.400	.....	28	34
46	Chisholm.....	77	4	23	.299	.....	24	44
47	Huffman×Chisholm.....	79	8	214	.272	—14	24	44
48	Huffman.....	77	0	18	.234	.....	16	36

The cross outyields the better parent in 8 comparisons out of the 14, the increase ranging from 2 to 31 per cent; in the remaining 6 comparisons the better parent outyields the cross by 1 to 9 per cent.

THE THREE TEXAS TESTS CONSIDERED COLLECTIVELY.

In considering the three tests collectively the relatively higher production of the Chisholm variety (male parent) at Sherman than at Waco and Corsicana is apparent. At Sherman it outyields the cross in 9 and the female parent in 10 out of 15 comparisons. At Waco it

outyields the cross in but 2 and the female in 5 out of 12 comparisons. At Corsicana it outyields the cross in 4 and the female parent in 5 out of 14 comparisons. The results at Waco and Corsicana are practically a reversal of the results with Chisholm at Sherman.

The 5 varieties that outyield Chisholm at Sherman are Surcropper, Dan Patch, Selection 137, Lily of the Valley, and Ferguson Yellow Dent. The first three varieties are earlier maturing than Chisholm; their increase in yield over Chisholm is considerably greater than the increase of Lily of the Valley and Ferguson Yellow Dent over Chisholm. This would indicate that the superiority of the first three varieties has been due chiefly to their earliness, which made them particularly suited to the drought conditions that prevailed at Sherman in 1910. From previous experience there is reason to believe that during a normal season Chisholm would be considerably more productive than any of these three varieties. The fourth variety (Lily of the Valley) is another strain of the same variety as Chisholm, its increase over Chisholm is not especially significant, although perhaps indicating a slight superiority, as Lily of the Valley outyielded Chisholm also at Corsicana. The increase of Ferguson Yellow over Chisholm is slight, and can not be regarded as indicating very much, if any, superiority. Taking into consideration the average behavior of Chisholm in all the rows in which it was planted, it perhaps should be considered as superior to any of the varieties for practical growing at Sherman.

The relatively greater productiveness of Chisholm in the Sherman test than at Waco and at Corsicana is due probably to the fact that Chisholm is a northern Texas variety, and the particular strain used in these experiments has been grown for many years on fertile black lands near Sherman. This doubtless has caused the variety to be better adapted to its environment at Sherman than it was at Waco or at Corsicana. Its yields also indicate that it was better adapted to the Sherman environment than were the other varieties in the test. The higher yields of the three early maturing varieties does not seem to have been due to better adaptation, but rather that the abnormal conditions of the season were less disastrous to them than to the later maturing varieties. The increase of Ferguson Yellow Dent, itself a northern Texas variety, is so slight that no generalization is warranted that it is better adapted to the Sherman environment than is Chisholm.

Of the varieties used as female parents none has been bred for any length of time for the conditions encountered at any of the three places. At Sherman the conditions were very adverse and the yields very poor. At Waco, in the Brazos Valley, conditions were more favorable. The soil retained the moisture better than the soil at

Sherman and morë moisture was available for the growing crop; higher yields were made, but Chisholm seems to be less suited to the conditions than most of the other varieties. The female parents made an increase of 223 per cent in average production per stalk over their average production per stalk at Sherman; the same increase for Chisholm is 186 per cent. The results at Corsicana were similar and as pronounced, although actual yields were lower than at Waco.

As has been stated, Chisholm at Sherman, to which conditions it has been thoroughly adapted, outyielded the cross in 9 out of 15 comparisons. At Waco, planted in the deep, sandy soil of the Brazos Valley, conditions to which the variety is apparently not adapted, it is outyielded by the cross in 10 out of 12 comparisons. At Corsicana, under conditions to which it was apparently also not adapted, it is outyielded by the cross in 10 out of 14 comparisons.

In the Waco and Corsicana tests the crosses in the majority of comparisons outyielded the parent varieties. None of the varieties used in the tests had been bred for any length of time for the environmental conditions encountered at either place. At Sherman the Chisholm variety, which has been grown for many years in that locality, outyielded the crosses in most of the comparisons. This would indicate that in general a variety well adapted to its environment is not improved nor its productiveness increased by crossing with other varieties possibly less adapted to the environment. What results would be obtained by crossing varieties that have been bred in the same locality and under the same conditions for a long period will have to be determined by further experimental work. Although in this connection attention should be called to the fact that crosses with such varieties as McCullough, Ferguson Yellow, and Singleton (all established northern Texas varieties that have been bred under very similar conditions to Chisholm) are less productive than Chisholm.

THE PRODUCTIVITY OF THE PARENT VARIETIES AND ITS INFLUENCE UPON THE
PRODUCTIVITY OF THE CROSSES.

In Table XII an attempt has been made to trace as far as the fifth or sixth rank in yield the factors showing to what extent the highest yielding crosses are progeny of the highest yielding varieties; also to what extent the highest yielding crosses may be identical with the crosses showing highest percentage of gain over better parent.

Table XIII is a similar enumeration of the poorest yielding varieties, poorest yielding crosses, and crosses showing the greatest percentage of decrease as compared with the better parent.

In the Sherman test the six highest yielding crosses are identical with the crosses of the six highest yielding female parents, but they

do not rank in exactly the same order as the parent varieties. The crosses showing the greatest percentage of increase over the better parent are identical with four of the highest yielding crosses. In the list of poorest yielding crosses four are identical with four of the crosses of the poorest yielding female parents with Chisholm. The crosses showing the greatest percentage of decrease as compared with the better parent are the same as the poorest yielding crosses and, with one exception, are progeny of the poorest yielding female parents.

In the Waco test four of the highest yielding crosses are identical with four of the crosses of the highest yielding female parents. Of the crosses listed as showing the greatest percentage of increase over the better parent four are identical with four of the highest yielding crosses, three are progeny of three of the highest yielding female parents, and two are progeny of two of the poorest yielding female parents. Four of the poorest yielding crosses are progeny of four of the poorest yielding female parents. The two crosses that are less productive than the better parent are both progeny of low-yielding female parents.

TABLE XII.—*Relation of the highest yielding crosses and crosses showing highest percentage of increase to the highest yielding parents, in Texas, 1910.*

Locality.	Female parent (best yielding, in order of productiveness).		Cross.		High-yielding cross.		Cross showing high percentage of increase over better parent.	
	Variety.	Yield per stalk.	Variety (× Chisholm) and rank.	Yield per stalk.	Variety (× Chisholm) and rank.	Yield per stalk.	Variety (× Chisholm).	Gain.
Sherman.	(Surrecopper	Pounds.	Surrecopper, 2	Pounds.	Dan Patch, 1	Pounds.	Selection 136	Per cent.
	Dan Patch 1	0.238	Dan Patch, 1	0.219	Surrecopper, 2	0.247	Gourd Seed	23
	Selection 137	.218	Selection 137, 6	.247	Selection 136, 3	.219	Dan Patch	16
	Lily of the Valley 1	.182	Lily of the Valley, 4	.172	Lily of the Valley, 4	.196	Lily of the Valley	13
	Selection 136	.174	Selection 136, 3	.182	Gourd Seed, 5	.182		6
	Gourd Seed	.158	Gourd Seed, 5	.195	Selection 137, 6	.177		
Waco.	Gourd Seed	.143		.177				
	(Gourd Seed	.593	Gourd Seed, 1	.625	Gourd Seed, 1	.625	McCullough	29
	Munson	.556	Munson, 2	.577	Munson, 2	.577	Gorham Yellow	23
	Schleberle 1	.556	Schleberle, 4	.566	Selection 136, 3	.573	Ferguson Yellow	21
	Selection 136	.523	Selection 136, 3	.573	Schleberle, 4	.565	Selection 136	10
	Singleton	.496	Singleton, 7	.500	Ferguson Yellow, 5	.533	Gourd Seed	7
Corsicana.	(Dan Patch	.496	Dan Patch, 2	.464	Lily of the Valley, 1	.534	Lily of the Valley	31
	Selection 136	.422	Selection 136, 4	.437	Dan Patch, 2	.464	Gorham Yellow	24
	Surrecopper	.418	Surrecopper, 5	.408	Gourd Seed, 3	.442	McCullough	11
	Ferguson Yellow	.416	Ferguson Yellow, 8	.386	Selection 136, 4	.437	Gourd Seed	7
	Gourd Seed	.414	Gourd Seed, 3	.442	Surrecopper, 5	.408	Mosby Prolific	6
							Dan Patch	6

1 Not in the test at Waco.

2 Not in the test at Corsicana.

TABLE XIII.—*Relation of the lowest yielding crosses and crosses showing greatest percentage of decrease to the lowest yielding parents in Texas, 1910.*

Locality.	Female parent (poorest yielding in inverse order of productiveness).		Cross.		Poor-yielding cross.		Cross showing high percentage of decrease from better parent.	
	Variety.	Yield per stalk.	Variety (× Chisholm) and rank.	Yield per stalk.	Variety (× Chisholm) and rank.	Yield per stalk.	Variety (× Chisholm).	Decrease.
Sherman.	(Huffman ¹ .)	<i>Pounds.</i> 0.029	Huffman, 14.	<i>Pounds.</i> 0.089	Huffman, 14.	<i>Pounds.</i> 0.089	Mosby Prolific.	Per cent. 33
	Mosby Prolific.	.087	Mosby Prolific, 13.	.117	Scheberle, 14.	.089	Scheberle.	32
	Blow.	.089	Blow, 8.	.144	Mosby Prolific, 13.	.117	Huffman.	28
	Munson.	.093	Munson, 12.	.120	Munson, 12.	.120	Singleton.	22
	(Singleton.)	.112	Singleton, 11.	.122	Singleton, 11.	.122	Munson.	21
Waco.	(Selection 137.)	.300	Selection 137, 12.	.364	Selection 137, 12.	.364	Selection 137.	18
	McCullough.	.312	McCullough, 8.	.490	Mosby Prolific, 11.	.434	Mosby Prolific.	9
	Gorham Yellow.	.339	Gorham Yellow, 6.	.510	Surcropper, 10.	.485		
	Mosby Prolific.	.364	Mosby Prolific, 11.	.434	Blow, 6.	.453		
	(Blow.)	.373	Blow, 9.	.453	McCullough, 8.	.490		
Corbiana.	(Huffman.)	.264	Huffman, 13.	.273	Huffman, 13.	.273	Huffman.	9
	McCullough.	.313	McCullough, 11.	.346	Singleton, 12.	.323	Ferguson Yellow.	7
	Singleton.	.317	Singleton, 12.	.322	McCullough, 11.	.346	Selection 137.	2
	Gorham Yellow.	.319	Gorham Yellow, 7.	.366	Blow, 10.	.363	Munson.	2
	(Blow.)	.325	Blow, 10.	.363	Munson, 10.	.363	Surcropper.	2

¹ Not in test at Waco.

In the Corsicana test four of the highest yielding crosses are progeny of four of the highest yielding female parents. Among the crosses showing the greatest percentage increase over the better parent three are identical with three of the highest yielding crosses, two are progeny of the high-yielding female parents, and two are progeny of the poor-yielding female parents. Of the poorest yielding crosses, four are progeny of four of the poorest yielding female parents. Out of the crosses showing the greatest percentage of decrease from the better parent, one is the progeny of the poorest yielding female parent, and two are the progeny of two of the highest yielding female parents. Two are identical with two of the poorest yielding crosses.

It is evident in these tests that in general the most productive crosses have come from the most productive female parents; that the crosses showing the greatest percentage of increase over the better parents are in most instances identical with the highest yielding crosses. Likewise, in most cases, the poorest yielding crosses are from the poorest yielding female parents, as are also most of the crosses that show the greatest percentage of decrease in yield. There is no instance in which one of the highest yielding crosses springs from one of the poorest yielding female parents.

There are, however, both in the test at Waco and at Corsicana, two crosses (Gorham Yellow $\times$ Chisholm and McCullough $\times$ Chisholm) which stand high in the list of crosses showing greatest percentage increase over the better parent; they rank among the crosses in actual production per stalk sixth and eighth, respectively, at Waco, while at Corsicana the rank is seventh and eleventh. The female parents of these crosses are among the poorest yielding varieties at both places. These two comparisons are the most striking among the crosses in regard to increase over the parent varieties, but their actual yield is less than the best producing original varieties in the test, and there would be no incentive to grow them commercially.

These results would indicate the most promising method of securing increased yields to be by crossing the highest yielding varieties, but such a method would necessitate the previous testing of the varieties to ascertain the highest yielding, and the crosses could not then with certainty be depended upon to give increased yields, as is seen in the case of the cross Surcropper $\times$ Chisholm, which is less productive than Surcropper at both Sherman and Corsicana and but little more productive at Waco. Selection 137 $\times$ Chisholm is less productive than Selection 137 (the better parent) at Sherman, and less than Chisholm (the better parent) at Waco and at Corsicana. The crosses Gourd Seed $\times$ Chisholm and Selection 136 $\times$ Chisholm were

among the highest yielding in the three tests, the Dan Patch $\times$ Chisholm was not in the test at Waco, but at Sherman and at Corsicana it ranks among the highest yielders. These crosses also ranked well as regards percentage of increased yield over better parent.

Apparently, then, there are some varieties that combine well and their crosses will give decidedly increased yields; while the crosses of other varieties either show no improvement in yield, or an actual decrease. As no method is known of selecting the varieties the crosses of which can be depended upon to give increased yields, the importance of testing experimentally all crosses before growing them commercially may be readily appreciated by the farmer or corn grower who has in mind the betterment of his general crop by such methods of breeding.

TESTS AT STATESBORO, GA.

VARIETIES USED IN THE EXPERIMENTS.

ALDRICH PERFECTION.

Aldrich Perfection was obtained from a field near Barnwell, S. C. This variety is not very uniform in type, but has a large, deep, characteristic kernel. The kernel is very irregular in shape and gives the ear a very rough appearance. The variety is grown near Barnwell on very sandy land. As grown at Statesboro, it seemed poorly adapted the first year and the market quality was poor. During the second year it seemed better adapted and the market quality was fair.

COCKE PROLIFIC.

Cocke Prolific for this work was obtained from the North Carolina experiment station. The type showed much variation, but the variety has a characteristic appearance. As grown at Statesboro, the ears were fairly sound, but were seriously damaged by weevils. The adaptability was about the same both years.

MARLBORO PROLIFIC.

Marlboro Prolific was selected from a farm near Cheraw, S. C., where it has been grown for many years. The type of ear is not very uniform, but it has a characteristic appearance. The native soil of this variety is sandy, with sandy clay subsoil. As grown at Statesboro, Marlboro Prolific seemed to produce fairly well both years. The grain was seriously damaged by weevils, otherwise it was in good condition.

MOSBY PROLIFIC.

As grown at Montgomery, Ala., Mosby Prolific shows close selection and distinct type. The land upon which the corn was grown is low and flat. The soil is dark and is classed as limestone. As grown at Statesboro, the ears were fairly sound and seemed fairly well adapted during both seasons. It was seriously injured by weevils before harvesting.

NATIVE OF STATESBORO.

The variation in color indicates that the Native of Statesboro variety of corn is badly mixed, but the comparatively straight rows of well-formed, deep kernels and the shape of the ear show that it has had selection along certain lines. It has been grown on a farm near the one on which this test was made for 18 or 20 years, without the introduction of other seed, so far as is known. As grown in the test, the ears were fairly sound during both seasons. Weevils were found within practically all of the shucks, but only a small amount of damage had been done by the time the corn was harvested the first year and none the second year.

RODGERS WHITE DENT.

Rodgers White Dent was selected from a field near Darlington, S. C. The type of the ears and uniformity of the corn is probably more perfect than any other in the test. It has been the selection of one man for years. The land on which the corn has been grown is sandy, with sandy clay subsoil. As grown at Statesboro, the market quality was very good and during both seasons it seemed fairly well adapted.

SANDERS PROLIFIC.

As grown and developed at Danielsville, Ga., Sanders Prolific shows considerable selection and has a characteristic type. The seed used in these experiments was field selected. The field is upland and consists of a very poor red clay. Suitable seed could be found only where sediment had accumulated above the terraces. As grown at Statesboro, Ga., the ears tended to be chaffy and were badly damaged by weevils before harvesting. It was poorly adapted to Statesboro conditions in 1909, but one of the best, except for weevils, in 1910.

STATION YELLOW.

The Station Yellow variety of corn was obtained from the Alabama experiment station, and was especially recommended for resisting weevils. No selection was claimed for this corn, but it is known that it is a native of long standing at Auburn, Ala. It is

flinty and has a fairly uniform golden color. It has been grown largely upon poor upland clay. As grown at Statesboro, its market quality was fully the equal of any grown in the experiment. Weevils were found in practically all of the shucks, but little damage had been done at time of harvesting.

TINDAL.

The Tindal corn is a mixture of Marlboro Prolific with a native corn near Manning, S. C., where the variety is being grown. This seed was selected from the grower's field three or four years after the mixture had first been made. The type is mostly that of Marlboro Prolific, though there is considerable variation. In the Orange Judd Farmer's national corn test in 1906 this corn took first prize, with 182 bushels per acre. The soil on which this corn was grown is sandy, with sandy clay subsoil near surface. As grown at Statesboro, it performed much the same as Marlboro Prolific.

WHELCHER.

The Whelchel variety of corn was bred and developed at Gainesville, Ga., and is the result of crossing at least three varieties, one of which was Boone County White. The original ears used in this test were unusually large. The bushel from which the 10 ears were taken contained only 64 ears. Much variation is still seen in the type. The corn was developed on rich red-clay land. This variety proved poorly adapted to Statesboro conditions. Many ears developed poorly and many of those that did develop rotted in the husk. The market quality was unusually bad, and it was extremely difficult to obtain sufficiently strong germinating seed for the second year's work. The apparently high yield in 1910 was due at least to some extent to the moisture contained in the ears at harvest time. The quality of the corn was very poor.

WILLIAMSON.

The Williamson corn has been grown and selected near Darlington, S. C., for a good many years, and the type of ear, the kernels, and their rows are unusually uniform. The color, however, is not fixed and varies from nearly white to nearly yellow. In general the kernels are white or cream capped, shading into a yellow toward the cob. The cobs are mostly red, but there are some white ones. The variety has been developed on sandy soil with a sandy, clay subsoil, which at present is quite fertile. As grown at Statesboro the ears showed a slight tendency to spoil in the field, but its adaptation seemed to be nearly as good as the native seed, and it had not been greatly damaged by weevils when harvested.

WORK OF 1909.

Eleven varieties of corn represented by 10 ears of each were used.

The seed of the ears was not mixed, but planted in adjacent rows. The corn was dropped in hills, and two stalks, from 6 to 8 inches apart, were left in a hill.

Each hill represented two ears. In all 10 rows representing a variety the first plant in each hill was from the same ear. These plants served both as a standard of comparison and as a sire to the variety in that set of 10. The second plant in all hills of any one row represented one ear of a female parent and was detasseled.

Duplicate plantings were made from each of the ears. In one instance the standard or sire ears were of the Marlboro Prolific variety, and in the other instance the standard or sire ears were of the Rodgers White Dent variety.

The standard or sire ears used were also grouped and detasseled the same as the ears of the other varieties, so that a study of both the male and the female was afforded. Furthermore, by thus comparing the standards of all the varieties in the test the several varieties themselves could be compared.

The arrangement of the varieties with their pollen-bearing standards is given in Table XIV. The two fields in which the crossing was accomplished were well isolated.

TABLE XIV.—Arrangement of the varieties of corn with their pollen-bearing standards.

Variety receiving pollen.		Ear No. of sire.	
Ears Nos.—	Name.	Marlboro Prolific.	Rodgers White Dent.
1 to 10.....	Aldrich Perfection.....	8	22
1 to 10.....	Cocks Prolific.....	9	24
1 to 10.....	Marlboro Prolific.....	3	7
1 to 10.....	Mosby Prolific.....	2	2
1 to 10.....	Native of Statesboro.....	3	3
1 to 10.....	Rodgers White Dent.....	7	20
1 to 10.....	Sanders Prolific.....	1	1
1 to 10.....	Station Yellow.....	5	15
1 to 10.....	Tindal.....	10	14
1 to 10.....	Whelchel.....	4	4
1 to 10.....	Williamson.....	6	17

CHARACTER OF THE SOIL.

The crossing was accomplished in 1909 at Statesboro, Ga., on coastal plain sand. The soil where the Marlboro Prolific sire was used had a fairly compact, sandy, clay subsoil 10 to 12 inches below the surface, and the land was fairly fertile. The soil where the Rodgers White Dent sire was used had less clay in the subsoil, and the land was naturally less fertile.

CULTURE.

The land was plowed deep. No commercial fertilizer was applied direct to the corn where Marlboro Prolific was used as sire, the land having previously been fertilized for rape. A complete fertilizer at the rate of about 800 pounds per acre was applied to the land where the Rodgers sire was used. The land was listed with a turning plow, and the corn was planted in the bottom of the furrows. Eight square feet were allowed each plant, the rows being 4 feet apart each way. The cultivation was with sweeps and harrows, and the last cultivation left the land level.

HARVEST.

The corn was harvested when thoroughly dry in the field. The weights were taken separately of all ears grown on the standard or sire stalks and of all the ears grown on the detasseled stalks of a row, and the two weights were recorded separately. Only normal hills with normal surroundings were considered, and the number of these hills considered was recorded under the heading "Number of perfect hills."

WORK OF 1910.

Only a portion of the seed from the original ears of this experiment was planted in 1909. The remnant seed of each ear was preserved in a separate glass bottle at Washington, D. C., until the spring of 1910, when it was tested for germination and planted in comparison with crossed progeny that had been growing at Statesboro in 1909, as previously described.

VITALITY OF SEED TESTED BEFORE PLANTING.

Vitality tests were made by the Seed Laboratory of the United States Department of Agriculture of all the ears planted in the experiment. Each ear was represented in the germination test by 10 kernels from various parts of the ear. The results were recorded as so many kernels germinating strong and so many germinating weak. The pure or 2-year-old seed averaged about 90 per cent strong the spring of 1910, and was unusually uniform in this particular, but the vitality of the crossed seed was usually low, and in some cases it was impossible to obtain satisfactory seed, even though the best was chosen. The crossed progeny was represented by a single ear selected largely because its vitality was the best available.

Table XV shows the variability in the germinating power both within the variety and between the varieties.

TABLE XV.—*Germination record of 11 varieties of corn cross-fertilized with Marlboro Prolific pollen.*

Name of variety and character of germination.	Nos. of ears tested.										Average of 10 ears.
	1	2	3	4	5	6	7	8	9	10	
Aldrich Perfection:											
Strong.....	0	3	4	5	0	8	5	5	5	7	4.2
Weak.....	8	3	4	5	9	2	3	1	2	3	4.0
Cooke Prolific:											
Strong.....	9	10	10	5	8	5	9	8	10	5	7.9
Weak.....	1	0	0	4	2	4	1	2	0	5	1.9
Marlboro Prolific:											
Strong.....	10	8	4	6	7	6	10	10	10	8	7.9
Weak.....	0	2	5	3	3	3	0	0	0	2	1.8
Mosby Prolific:											
Strong.....	10	9	8	8	8	8	7	8	10	5	8.5
Weak.....	0	1	2	2	1	0	2	2	0	5	1.1
Native of Statesboro:											
Strong.....	10	10	10	7	10	10	5	7	7	8	8.4
Weak.....	0	0	0	3	0	0	5	3	3	2	1.6
Rodgers White Dent:											
Strong.....	9	9	10	10	10	10	9	10	10	8	9.5
Weak.....	1	1	0	0	0	0	1	0	0	2	.5
Sanders Prolific:											
Strong.....	5	7	10	8	9	3	5	0	2	4	5.3
Weak.....	2	1	0	1	1	4	5	10	7	5	3.6
Station Yellow:											
Strong.....	10	1	6	8	7	10	8	10	6	4	7.0
Weak.....	0	9	4	1	3	0	2	0	3	5	2.7
Tindal:											
Strong.....	8	10	9	10	10	9	10	8	8	10	9.2
Weak.....	2	0	1	0	0	1	0	0	2	0	.6
Wheelchel:											
Strong.....	2	0	0	5	3	7	0	3	3	0	2.3
Weak.....	7	5	9	5	6	3	7	4	7	10	6.3
Williamson:											
Strong.....	10	10	10	5	10	5	6	9	4	9	7.8
Weak.....	0	0	0	2	0	5	3	0	6	0	1.6

An unusual quantity of this seed was planted in each hill and later thinned to the stand desired. When the corn came up and started to grow, the vigor of the crossed and of the uncrossed plants was not noticeably different. The productiveness of the female parents in comparison with the first-generation crosses was tested at Statesboro, and upon the same farm where the crosses were produced the previous year, but in a different field. The field had been brought into cultivation more recently than those used in 1909, and although not rich it was quite uniformly fertile.

The seed was planted in hills, and two stalks were left to the hill. The stalks stood from 6 to 8 inches apart in the hill. The first member of each hill in a row was from the remnant seed, and the second member of the hill was progeny of the first, which had been cross-pollinated the previous year.

PLAN OF TESTING PRODUCTIVENESS IN 1910.

Diagram 2 shows the arrangement of this 1910 planting. The varieties were planted in alphabetical order, and their ears in numerical order. As shown in the plan, each hill, for example, of row 1 in section 1 contained two stalks; the first stalk was from original ear 1 of Aldrich Perfection, and the second stalk from an ear descending directly from ear 1 of Aldrich Perfection, and which was cross-pollinated in 1909 with pollen from Rodgers White Dent.

DIAGRAM 2.—Plan of testing plats for comparing the productiveness in 1910 of original pure-bred ears of corn and their crossbred progeny ears.

[Key to the varieties and their crossbred progeny (10 ears of each and 10 rows of each except of *T*): *A*, Aldrich Perfection and its cross with Rodgers White Dent; *B*, Aldrich Perfection and its cross with Marlboro Prolific; *C*, Cocke Prolific and its cross with Rodgers White Dent; *D*, Cocke Prolific and its cross with Marlboro Prolific; *E*, Marlboro Prolific and its cross with Rodgers White Dent; *F*, Marlboro Prolific and its cross with Marlboro Prolific; *G*, Mosby Prolific and its cross with Rodgers White Dent; *H*, Mosby Prolific and its cross with Marlboro Prolific; *I*, Native of Statesboro and its cross with Rodgers White Dent; *J*, Native of Statesboro and its cross with Marlboro Prolific; *K*, Rodgers White Dent and its cross with Rodgers White Dent; *L*, Rodgers White Dent and its cross with Rodgers White Dent; *M*, Sanders Prolific and its cross with Rodgers White Dent; *N*, Sanders Prolific and its cross with Marlboro Prolific; *O*, Station Yellow and its cross with Rodgers White Dent; *P*, Station Yellow and its cross with Marlboro Prolific; *Q*, Tindal and its cross with Rodgers White Dent; *R*, Tindal and its cross with Marlboro Prolific; *S*, Wheelchel and its cross with Rodgers White Dent; *T*, Wheelchel and its cross with Marlboro Prolific (17 rows); *U*, Williamson and its cross with Rodgers White Dent; *V*, Williamson and its cross with Marlboro Prolific.]

Section 1.	Section 2.	Section 3.	Section 4.	Section 5.	Section 6.	Section 7.
1 2 3 4 5 6 7 8 9 10 A 1 2 3 4 5 6 7 8 9 10 B	3 4 5 6 7 8 9 10 D	5 6 7 8 9 10 G	7 8 9 10 J	9 10 M	1 2 3 4 5 6 7 8 9 10 Q	3 4 5 6 7 8 9 10 T
1 2 3 4 5 6 7 8 9 10 B	1 2 3 4 5 6 7 8 9 10 E	1 2 3 4 5 6 7 8 9 10 H	1 2 3 4 5 6 7 8 9 10 K	1 2 3 4 5 6 7 8 9 10 N	1 2 3 4 5 6 7 8 9 10 R	1 2 3 4 5 6 7 8 9 10 U
1 2 3 4 5 6 7 8 9 10 C	1 2 3 4 5 6 7 8 9 10 F	1 2 3 4 5 6 7 8 9 10 I	1 2 3 4 5 6 7 8 9 10 L	1 2 3 4 5 6 7 8 9 10 O	1 2 3 4 5 6 7 8 9 10 S	1 2 3 4 5 6 7 8 9 10 V
1 2 3 4 5 6 7 8 9 10 D	1 2 3 4 5 6 7 8 9 10 G	1 2 3 4 5 6 7 8 9 10 J	1 2 3 4 5 6 7 8 9 10 M	1 2 3 4 5 6 7 8 9 10 P	1 2 3 4 5 6 7 8 9 10 T	1 2 3 4 5 6 7 8 9 10 W

Tenant's cabin 

North.

1 The end at the south end of section 7 was unusually rich, and the stand was made thinner because of chickens of near-by tenant.

CONDITIONS FOR GROWTH.

The land had been thoroughly plowed several weeks previous to planting. Just before planting, furrows were opened with a large shovel, which not only permitted planting below the level in moist earth, but also helped to throw to one side hidden obstructions that might interfere with a uniform thrust of the hand planters used.

A marked wire was used to regulate both the spacing of the hills in the row and the spacing of the stalks in the hills.

The writer and his assistant planted all of the seed. Each man carried seed for a certain member of the hill only, and together they planted each hill. On removing the planter from the ground the foot was placed upon the spot and the weight of the body was thrown upon it in stepping forward to the next hill. Care was taken to remove trash or any other obstruction that might interfere with proper planting.

Nine square feet per plant were allowed, so that very little competition for sunlight was possible among the plants. The rainfall was abundant except for a week or 10 days previous to tasseling. A liberal supply of commercial fertilizer was used.

Abnormal growth (barrenness, smut, etc.) was very rare among the plants, but there were missing members of some hills and a few missing hills. However, in securing the data that follow, consideration was taken only of hills that grew under normal conditions and whose members seemed to have had equal opportunity and were normal.

MANNER OF HARVESTING.

The harvesting was done by four men. One carried a notebook and kept all of the records. Another carried a knife and selected and cut the hills of a row that were suitable. The other two men took the stalks as they were cut, one carrying the first member only and the other carrying the second member only.

The fodder was thus collected and carried to the end of the rows and there weighed, and the collective weights of the two members of each hill were recorded separately.

The ears were then separated from the stover, and the weight of each together with the number of ears was recorded.

MOISTURE IN GRAIN HARVESTED.

Through the courtesy of the Office of Grain Standardization moisture determinations were obtained of grain shelled from many ears of each variety and each cross. The extreme variation among the varieties and crosses was less than 2 per cent of moisture. The shelled grain of Aldrich Perfection and Whelchel contained 16 per

cent of moisture, and the other varieties and crosses contained about 1 per cent less. The appearance of the large cobs of the Whelchel and Aldrich Perfection varieties and the rotting of the ears indicated that the entire ears of these varieties contained a greater excess of moisture than did the shelled grain. In these two cases a correction for moisture content would give a more valuable comparison, but since the moisture content of the entire ears was not determined the comparisons of productiveness are in all cases based on the weight of ears as harvested.

PRESENTATION OF RESULTS IN GEORGIA.

DATA COLLECTED AT HARVEST.

Table XVI gives in detail the data collected at harvest time in 1910.

TABLE XVI.—Yield record of 11 varieties of corn and their crossed progeny tested at Statesboro, Ga.

ALDRICH PERFECTION ♀ × MARLBORO PROLIFIC ♂.¹

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds).					Per cent of difference.	Number of ears produced.	
			Total.		Per stalk.				Original.	Cross.
			Original.	Cross.	Original.	Cross.	Difference.			
1	14	Ears.....	9.75	9.50	0.70	0.68	-0.02	- 3	15	14
		Stalks.....	13.75	14.25	.98	1.02	.04	4		
2	8	Ears.....	4.25	5.00	.53	.63	.10	18	8	7
		Stalks.....	6.25	8.25	.78	1.03	.25	32		
3	12	Ears.....	5.75	7.25	.48	.60	.12	26	12	12
		Stalks.....	8.75	11.50	.73	.96	.23	31		
4	19	Ears.....	11.00	11.50	.58	.61	.03	5	20	19
		Stalks.....	15.25	17.25	.80	.91	.11	13		
5	12	Ears.....	6.75	7.75	.56	.65	.09	15	13	12
		Stalks.....	10.00	11.50	.83	.96	.13	15		
6	14	Ears.....	4.25	8.50	.30	.61	.31	100	14	14
		Stalks.....	17.00	12.75	1.21	.91	-.30	- 25		
7	13	Ears.....	8.50	6.75	.65	.52	-.13	- 21	13	13
		Stalks.....	16.25	10.25	1.25	.79	-.46	- 37		
8	8	Ears.....	5.00	5.00	.63	.63	.00	0	8	8
		Stalks.....	8.00	7.50	1.00	.94	-.06	- 6		
9	16	Ears.....	4.50	7.25	.28	.45	.17	61	16	16
		Stalks.....	15.75	12.25	.98	.77	-.21	- 22		
10	16	Ears.....	8.75	8.00	.55	.50	-.05	- 9	16	16
		Stalks.....	13.00	11.25	.81	.70	-.11	- 13		

¹ Favoring the cross: Ears, 6 out of 10; stalks, 5 out of 10. Average weight of ears per stalk produced by the female parent, 0.52 pound; by the cross, 0.58 pound. Average weight of stover per stalk produced by female parent, 0.94 pound; by the cross, 0.88 pound. Increased yield of cross over the female parent: Grain, 12 per cent; stover, -6 per cent.

TABLE XVI.—Yield record of 11 varieties of corn and their crossed progeny tested at Statesboro, Ga.—Continued.

ALDRICH PERFECTION ♀ × RODGERS WHITE DENT ♂.¹

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds).					Per cent of difference.	Number of ears produced.	
			Total.		Per stalk.				Original.	Cross.
			Original.	Cross.	Original.	Cross.	Difference.			
1	14	Ears	8.00	6.25	0.57	0.45	-0.12	- 22	14	14
		Stalks	9.50	12.50	.68	.89	.21	32		
2	21	Ears	11.25	13.00	.54	.62	.08	16	21	21
		Stalks	17.25	20.25	.82	.96	.14	17		
3	8	Ears	3.25	5.00	.41	.63	.22	54	8	9
		Stalks	7.25	8.00	.91	1.00	.09	10		
4	24	Ears	13.25	13.25	.55	.55	.00	0	24	25
		Stalks	19.50	21.00	.81	.88	.07	8		
5	14	Ears	7.25	8.00	.52	.57	.05	10	14	15
		Stalks	11.00	12.50	.79	.89	.10	14		
6	18	Ears	8.50	11.50	.47	.64	.17	35	18	20
		Stalks	14.00	16.75	.78	.93	.15	20		
7	15	Ears	9.25	9.75	.62	.65	.03	5	15	19
		Stalks	14.50	16.00	.97	1.07	.10	10		
8	17	Ears	9.25	11.00	.54	.65	.11	19	17	17
		Stalks	14.75	17.75	.87	1.04	.17	20		
9	8	Ears	3.75	5.25	.47	.66	.19	40	8	10
		Stalks	6.25	8.00	.78	1.00	.22	28		
10	12	Ears	7.50	6.75	.63	.56	-.07	-10	12	12
		Stalks	10.75	10.50	.90	.88	-.02	- 2		

COCKE PROLIFIC ♀ × MARLBORO PROLIFIC ♂.²

1	22	Ears.....	10.25	10.50	0.47	0.48	0.01	2	25	24
		Stalks.....	17.25	16.00	.78	.73	-.05	- 7		
2	18	Ears.....	10.50	10.50	.58	.58	.00	0	20	23
		Stalks.....	16.00	15.75	.89	.88	-.01	- 2		
3	21	Ears.....	9.00	10.00	.43	.48	.05	11	21	23
		Stalks.....	13.00	14.25	.62	.68	.06	10		
4	20	Ears.....	10.00	8.75	.50	.44	-.06	-13	21	20
		Stalks.....	16.50	13.50	.83	.68	-.15	-18		
5	18	Ears.....	10.50	10.25	.58	.57	-.01	- 2	25	25
		Stalks.....	16.00	14.75	.89	.82	-.07	- 8		
6	23	Ears.....	10.75	13.50	.47	.59	.12	26	29	28
		Stalks.....	17.25	20.50	.75	.89	.14	19		
7	24	Ears.....	11.75	12.50	.49	.52	.03	6	27	25
		Stalks.....	20.25	19.25	.84	.80	-.04	- 5		
8	19	Ears.....	11.00	12.00	.58	.63	.05	9	24	28
		Stalks.....	17.00	17.25	.89	.91	.02	1		
9	21	Ears.....	9.00	12.50	.43	.60	.17	39	21	30
		Stalks.....	14.50	19.75	.69	.94	.25	36		
10	18	Ears.....	11.00	11.75	.61	.65	.04	7	28	23
		Stalks.....	18.25	17.50	1.01	.97	-.04	- 4		

¹ Favoring the cross: Ears, 7 out of 10; stalks, 9 out of 10. Average weight of ears per stalk produced by the female parent, 0.54 pound; by the cross, 0.50 pound. Average weight of stover per stalk produced by female parent, 0.83 pound; by the cross, 0.95 pound. Increased yield of cross over the female parent: Grain, 10 per cent; stover, 15 per cent.

² Favoring the cross: Ears, 7 out of 10; stalks, 4 out of 10. Average weight of ears per stalk produced by the female parent, 0.51 pound; by the cross, 0.55 pound. Average weight of stover per stalk produced by female parent, 0.81 pound; by the cross, 0.83 pound. Increased yield of cross over the female parent: Grain, 8 per cent; stover, 2 per cent.

TABLE XVI.—Yield record of 11 varieties of corn and their crossed progeny tested at Statesboro, Ga.—Continued.

COCKE PROLIFIC ♀ × RODGERS WHITE DENT ♂.¹

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds).					Per cent of difference.	Number of ears produced.	
			Total.		Per stalk.				Original.	Cross.
			Original.	Cross.	Original.	Cross.	Difference.			
1	13	Ears.....	6.75	5.75	0.52	0.44	—0.08	—15	13	13
		Stalks.....	12.00	9.25	.92	.71	— .21	—23		
2	18	Ears.....	9.25	10.00	.51	.56	.05	8	18	20
		Stalks.....	14.00	14.50	.78	.81	.03	4		
3	21	Ears.....	9.00	10.00	.43	.48	.05	11	22	22
		Stalks.....	12.75	15.25	.61	.73	.12	20		
4	18	Ears.....	8.25	7.00	.46	.39	— .07	—15	20	18
		Stalks.....	14.25	10.00	.79	.56	— .23	—30		
5	12	Ears.....	5.75	4.25	.48	.35	— .13	—26	13	12
		Stalks.....	8.75	6.25	.73	.52	— .21	—29		
6	14	Ears.....	6.25	6.75	.45	.48	.03	8	16	14
		Stalks.....	9.75	9.25	.70	.66	— .04	—5		
7	21	Ears.....	10.25	10.50	.49	.50	.01	2	22	21
		Stalks.....	16.25	15.25	.77	.73	— .04	—6		
8	23	Ears.....	11.75	13.75	.51	.60	.09	17	28	31
		Stalks.....	17.00	19.50	.74	.85	.11	15		
9	21	Ears.....	9.00	9.50	.43	.45	.02	6	25	22
		Stalks.....	14.50	16.00	.69	.76	.07	10		
10	15	Ears.....	6.50	7.25	.43	.48	.05	12	16	17
		Stalks.....	9.25	10.50	.62	.70	.08	14		

MARLBORO PROLIFIC ♀ × MARLBORO PROLIFIC ♂.²

1	21	Ears.....	10.75	11.00	0.51	0.52	0.01	2	27	27
		Stalks.....	19.00	17.25	.90	.82	— .08	—9		
2	18	Ears.....	9.25	11.50	.51	.64	.13	24	19	25
		Stalks.....	14.50	18.75	.81	1.04	.23	29		
3	21	Ears.....	11.00	12.00	.52	.57	.05	9	25	28
		Stalks.....	18.50	21.25	.88	1.01	.13	15		
4	20	Ears.....	10.75	8.00	.54	.40	— .14	—26	22	30
		Stalks.....	16.25	13.25	.81	.66	— .15	—18		
5	15	Ears.....	7.75	6.50	.52	.43	— .09	—16	20	16
		Stalks.....	13.25	11.25	.88	.75	— .13	—15		
6	19	Ears.....	9.00	10.00	.47	.53	.06	11	23	22
		Stalks.....	13.50	15.25	.71	.80	.09	13		
7	22	Ears.....	9.75	12.25	.44	.56	.12	26	26	33
		Stalks.....	15.25	19.25	.69	.88	.19	26		
8	25	Ears.....	11.50	14.25	.46	.57	.11	24	29	38
		Stalks.....	19.50	21.75	.78	.87	.09	12		
9	23	Ears.....	12.25	10.75	.53	.47	— .06	—12	30	26
		Stalks.....	19.00	17.00	.53	.74	— .09	—11		
10	23	Ears.....	10.00	9.25	.43	.40	— .03	—8	27	24
		Stalks.....	16.00	13.75	.70	.60	— .10	—14		

¹ Favoring the cross: Ears, 7 out of 10; stalks, 5 out of 10. Average weight of ears per stalk produced by the female parent, 0.47 pound; by the cross, 0.48 pound. Average weight of stover per stalk produced by female parent, 0.73 pound; by the cross, 0.71 pound. Increased yield of cross over the female parent: Grain, 2 per cent; stover, 2 per cent.

² Favoring the cross: Ears, 6 out of 10; stalks, 5 out of 10. Average weight of ears per stalk produced by the female parent, 0.49 pound; by the cross, 0.51 pound. Average weight of stover per stalk produced by female parent, 0.80 pound; by the cross, 0.82 pound. Increased yield of cross over the female parent: Grain, 3 per cent; stover, 2 per cent.

TABLE XVI.—Yield record of 11 varieties of corn and their crossed progeny tested at Statesboro, Ga.—Continued.

MARLBORO PROLIFIC ♀ × RODGERS WHITE DENT ♂.¹

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds).					Per cent of difference.	Number of ears produced.	
			Total.		Per stalk.				Original.	Cross.
			Original.	Cross.	Original.	Cross.	Difference.			
1	25	Ears.....	14.50	13.25	0.58	0.53	-0.05	-9	33	28
		Stalks.....	26.50	25.25	1.06	1.01	-.06	-5		
2	26	Ears.....	12.50	14.00	.48	.54	.06	12	28	27
		Stalks.....	21.00	25.00	.81	.96	.15	19		
3	22	Ears.....	11.50	12.00	.52	.55	.03	4	29	27
		Stalks.....	19.75	23.25	.90	1.06	.16	18		
4	26	Ears.....	14.50	15.00	.58	.60	.02	3	37	27
		Stalks.....	26.25	26.75	1.05	1.07	.02	2		
5	22	Ears.....	12.00	13.00	.55	.59	.04	8	27	28
		Stalks.....	21.00	23.00	.95	1.05	.10	10		
6	21	Ears.....	11.00	12.00	.52	.57	.05	9	28	23
		Stalks.....	18.50	21.00	.88	1.00	.12	14		
7	24	Ears.....	10.75	13.50	.45	.56	.11	26	29	28
		Stalks.....	19.00	23.50	.79	.98	.19	24		
8	21	Ears.....	12.00	11.75	.57	.56	-.01	-2	29	22
		Stalks.....	22.00	19.50	1.05	.93	-.12	-11		
9	18	Ears.....	10.50	10.50	.58	.58	.00	0	22	20
		Stalks.....	17.00	17.25	.94	.96	.02	1		
10	15	Ears.....	7.50	10.00	.50	.67	.17	33	15	22
		Stalks.....	12.75	15.75	.85	1.05	.20	24		

MOSEBY PROLIFIC ♀ × MARLBORO PROLIFIC ♂.²

1	25	Ears.....	12.00	13.75	0.48	0.55	0.07	15	35	34
		Stalks.....	21.00	22.75	.94	.91	-.03	-3		
2	20	Ears.....	12.50	13.00	.63	.65	.02	4	34	30
		Stalks.....	20.00	20.00	1.00	1.00	.00	0		
3	19	Ears.....	8.00	10.00	.42	.53	.11	25	24	25
		Stalks.....	14.50	16.50	.76	.87	.11	14		
4	19	Ears.....	8.75	9.50	.46	.50	.04	9	20	20
		Stalks.....	14.25	15.50	.75	.82	.07	9		
5	20	Ears.....	9.00	11.75	.45	.59	.14	31	22	26
		Stalks.....	15.50	18.25	.78	.91	.13	18		
6	16	Ears.....	7.75	9.25	.48	.58	.10	19	19	18
		Stalks.....	13.75	14.75	.86	.92	.06	7		
7	17	Ears.....	8.25	9.00	.49	.53	.04	9	19	18
		Stalks.....	14.00	14.00	.82	.82	.00	0		
8	13	Ears.....	8.00	8.75	.62	.67	.05	9	18	19
		Stalks.....	13.75	15.25	1.06	1.17	.11	11		
9	17	Ears.....	8.75	9.00	.51	.53	.02	3	18	23
		Stalks.....	15.00	14.00	.88	.82	-.06	-7		
10	23	Ears.....	9.00	10.00	.39	.43	.04	11	23	25
		Stalks.....	18.00	18.00	.78	.78	.00	0		

¹ Favoring the cross: Ears, 7 out of 10; stalks, 8 out of 10. Average weight of ears per stalk produced by the female parent, 0.53 pound; by the cross, 0.57 pound. Average weight of stover per stalk produced by female parent, 0.93 pound; by the cross, 1.01 pounds. Increased yield of cross over the female parent: Grain, 7 per cent; stover, 8 per cent.

² Favoring the cross: Ears, 10 out of 10; stalks, 6 out of 10. Average weight of ears per stalk produced by the female parent, 0.49 pound; by the cross, 0.55 pound. Average weight of stover per stalk produced by female parent, 0.85 pound; by the cross, 0.89 pound. Increased yield of cross over the female parent: Grain, 13 per cent; stover, 6 per cent.

TABLE XVI.—Yield record of 11 varieties of corn and their crossed progeny tested at Statesboro, Ga.—Continued.

MOSBY PROLIFIC ♀ × RODGERS WHITE DENT ♂.¹

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds).					Per cent of difference.	Number of ears produced.	
			Total.		Per stalk.				Original.	Cross.
			Original.	Cross.	Original.	Cross.	Difference.			
1	18	Ears.....	6.75	10.00	0.38	0.56	0.18	48	25	23
		Stalks.....	13.00	15.75	.72	.88	.16	21		
2	17	Ears.....	6.75	8.25	.40	.49	.09	22	18	20
		Stalks.....	11.25	12.25	.66	.72	.06	9		
3	22	Ears.....	8.75	12.50	.40	.57	.17	43	27	31
		Stalks.....	14.75	20.25	.67	.92	.25	37		
4	18	Ears.....	9.00	11.50	.50	.64	.14	28	21	22
		Stalks.....	14.50	18.50	.81	1.03	.22	28		
5	22	Ears.....	8.50	11.00	.39	.50	.11	29	22	27
		Stalks.....	14.25	17.50	.65	.80	.15	23		
6	20	Ears.....	8.50	11.50	.45	.58	.13	35	23	27
		Stalks.....	14.75	18.00	.74	.90	.16	22		
7	22	Ears.....	10.25	12.75	.47	.58	.11	24	25	27
		Stalks.....	17.25	20.50	.78	.93	.15	19		
8	23	Ears.....	10.25	13.00	.45	.57	.12	27	31	26
		Stalks.....	19.50	21.75	.85	.95	.10	12		
9	18	Ears.....	10.00	10.75	.56	.60	.04	8	22	22
		Stalks.....	16.75	18.50	.93	1.03	.10	10		
10	26	Ears.....	10.75	13.75	.43	.55	.12	28	28	28
		Stalks.....	20.25	23.25	.81	.93	.12	15		

NATIVE OF STATESBORO ♀ × MARLBORO PROLIFIC ♂.²

1	21	Ears.....	13.25	12.75	0.63	0.61	-.02	- 4	22	23
		Stalks.....	21.25	20.00	1.01	.95	-.06	- 6	.....	.....
2	20	Ears.....	10.75	11.50	.54	.58	.04	7	21	22
		Stalks.....	17.50	18.00	.88	.90	.02	3	.....	.....
3	7	Ears.....	3.25	3.25	.46	.46	.00	0	7	8
		Stalks.....	5.50	5.00	.79	.71	-.08	- 9	.....	.....
4	23	Ears.....	11.25	12.25	.49	.53	.04	9	24	25
		Stalks.....	18.75	21.50	.82	.93	.11	15	.....	.....
5	21	Ears.....	9.00	10.50	.43	.50	.07	17	22	21
		Stalks.....	15.25	17.75	.73	.85	.12	16	.....	.....
6	13	Ears.....	7.00	6.75	.54	.52	-.02	- 4	14	14
		Stalks.....	11.00	11.50	.85	.88	.03	5	.....	.....
7	15	Ears.....	7.25	7.00	.48	.47	-.01	- 3	15	16
		Stalks.....	11.25	11.00	.75	.73	-.02	- 2	.....	.....
8	10	Ears.....	6.00	6.25	.60	.63	.03	4	11	15
		Stalks.....	10.00	10.50	1.00	1.05	.05	5	.....	.....
9	18	Ears.....	7.75	10.00	.43	.56	.13	29	18	19
		Stalks.....	13.25	15.25	.74	.85	.11	15	.....	.....
10	13	Ears.....	6.75	7.00	.52	.54	.02	4	13	14
		Stalks.....	9.75	10.50	.75	.81	.06	8	.....	.....

¹ Favoring the cross: Ears, 10 out of 10; stalks, 10 out of 10. Average weight of ears per stalk produced by the female parent, 0.44 pound; by the cross, 0.56 pound. Average weight of stover per stalk produced by female parent, 0.76 pound; by the cross, 0.91 pound. Increased yield of cross over the female parent: Grain, 28 per cent; stover, 19 per cent.

² Favoring the cross: Ears, 6 out of 10; stalks, 7 out of 10. Average weight of ears per stalk produced by the female parent, 0.51 pound; by the cross, 0.54 pound. Average weight of stover per stalk produced by female parent, 0.83 pound; by the cross, 0.88 pound. Increased yield of cross over the female parent: Grain, 6 per cent; stover, 6 per cent.

TABLE XVI.—Yield record of 11 varieties of corn and their crossed progeny tested at Statesboro, Ga.—Continued.

NATIVE OF STATESBORO ♀ × RODGERS WHITE DENT ♂.¹

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds).					Per cent of difference.	Number of ears produced.	
			Total.		Per stalk.				Original.	Cross.
			Original.	Cross.	Original.	Cross.	Difference.			
1	15	Ears.....	9.50	7.50	0.63	0.50	-0.13	-21	17	15
		Stalks.....	15.50	12.75	1.03	.85	-.18	-18	.....	.....
2	18	Ears.....	10.75	11.00	.60	.61	.01	2	19	22
		Stalks.....	18.75	18.50	1.04	1.03	-.01	-1	.....	.....
3	11	Ears.....	7.25	7.25	.66	.66	.00	0	12	14
		Stalks.....	12.25	12.25	1.11	1.11	.00	0	.....	.....
4	12	Ears.....	7.00	6.00	.58	.50	-.08	-14	12	12
		Stalks.....	12.25	9.50	1.02	.79	-.23	-22	.....	.....
5	17	Ears.....	9.50	10.50	.56	.62	.06	11	17	17
		Stalks.....	16.50	17.50	.97	1.03	.06	6	.....	.....
6	11	Ears.....	5.50	6.00	.50	.55	.05	9	12	11
		Stalks.....	11.50	10.50	1.05	.95	-.10	-9	.....	.....
7	18	Ears.....	8.00	8.25	.44	.46	.02	3	18	20
		Stalks.....	15.00	14.25	.83	.79	-.04	-5	.....	.....
8	19	Ears.....	8.25	10.50	.43	.55	.12	27	19	19
		Stalks.....	14.50	18.75	.76	.99	.23	29	.....	.....
9	22	Ears.....	7.75	12.00	.35	.55	.20	55	23	22
		Stalks.....	14.00	20.50	.64	.93	.29	46	.....	.....
10	21	Ears.....	9.75	9.75	.46	.46	.00	0	21	21
		Stalks.....	14.25	16.75	.68	.80	.12	18	.....	.....

RODGERS WHITE DENT ♀ × MARLBORO PROLIFIC ♂.²

1	18	Ears.....	10.00	10.75	0.56	0.60	0.04	8	18	24
		Stalks.....	15.50	16.75	.86	.93	.07	8	.....	.....
2	22	Ears.....	11.50	11.00	.52	.50	-.02	-4	26	22
		Stalks.....	16.75	17.00	.76	.77	.01	1	.....	.....
3	19	Ears.....	9.75	12.00	.51	.63	.12	23	22	23
		Stalks.....	15.75	19.00	.83	1.00	.17	21	.....	.....
4	21	Ears.....	12.00	11.75	.57	.56	-.01	-2	28	27
		Stalks.....	17.50	18.75	.83	.89	.06	7	.....	.....
5	25	Ears.....	11.75	13.00	.47	.52	.05	11	25	30
		Stalks.....	18.25	20.50	.73	.82	.09	12	.....	.....
6	17	Ears.....	7.50	10.25	.44	.60	.16	37	17	19
		Stalks.....	12.25	15.25	.72	.90	.18	24	.....	.....
7	22	Ears.....	10.00	10.50	.45	.48	.03	5	22	22
		Stalks.....	15.75	16.75	.72	.76	.04	6	.....	.....
8	17	Ears.....	9.25	9.25	.54	.54	.00	0	17	19
		Stalks.....	14.50	14.75	.85	.87	.02	2	.....	.....
9	12	Ears.....	5.25	6.75	.44	.56	.12	28	13	14
		Stalks.....	8.00	11.00	.67	.92	.25	38	.....	.....
10	17	Ears.....	8.50	9.50	.50	.56	.06	12	19	20
		Stalks.....	13.50	15.00	.79	.88	.09	11	.....	.....

¹ Favoring the cross: Ears, 6 out of 10; stalks, 4 out of 10. Average weight of ears per stalk produced by the female parent, 0.51 pound; by the cross, 0.54 pound. Average weight of stover per stalk produced by female parent, 0.83 pound; by the cross, 0.92 pound. Increased yield of cross over the female parent: Grain, 7 per cent; stover, 5 per cent.

² Favoring the cross: Ears, 7 out of 10; stalks, 10 out of 10. Average weight of ears per stalk produced by the female parent, 0.50 pound; by the cross, 0.55 pound. Average weight of stover per stalk produced by female parent, 0.78 pound; by the cross, 0.87 pound. Increased yield of cross over the female parent: Grain, 10 per cent; stover, 12 per cent.

TABLE XVI.—Yield record of 11 varieties of corn and their crossed progeny tested at Statesboro, Ga.—Continued.

RODGERS WHITE DENT ♀ × RODGERS WHITE DENT ♂.¹

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds).					Per cent of difference.	Number of ears produced.	
			Total.		Per stalk.				Original.	Cross.
			Original.	Cross.	Original.	Cross.	Difference.			
1	11	Ears.....	7.00	5.25	0.64	0.48	-0.16	-25	13	11
		Stalks.....	11.25	8.25	1.02	.75	-.27	-27	28	25
2	23	Ears.....	13.25	11.25	.58	.49	-.09	-15	28	25
		Stalks.....	21.25	17.00	.92	.74	-.18	-20	14	14
3	14	Ears.....	7.25	6.75	.52	.48	-.04	-7	31	28
		Stalks.....	11.00	10.75	.79	.77	-.02	-2	2	2
4	22	Ears.....	13.25	13.50	.60	.61	.01	2	28	25
		Stalks.....	21.00	22.00	.95	1.00	.05	5	22	22
5	22	Ears.....	12.50	9.75	.57	.44	-.13	-22	22	22
		Stalks.....	19.75	16.00	.90	.73	-.17	-19	22	22
6	22	Ears.....	10.75	9.75	.49	.44	-.05	-9	16	18
		Stalks.....	17.50	14.50	.80	.66	-.14	-17	0	16
7	16	Ears.....	8.25	8.25	.52	.52	.00	0	20	21
		Stalks.....	13.50	12.75	.84	.80	-.04	-6	20	21
8	20	Ears.....	13.50	10.50	.68	.53	-.15	-22	18	16
		Stalks.....	21.25	15.25	1.06	.76	-.30	-28	18	16
9	16	Ears.....	7.50	8.25	.47	.52	.05	10	22	21
		Stalks.....	11.50	13.25	.72	.83	.11	15	22	21
10	20	Ears.....	10.00	11.50	.50	.58	.08	15	18	18
		Stalks.....	15.50	18.25	.78	.91	.13	18	18	18

SANDERS PROLIFIC ♀ × MARLBORO PROLIFIC ♂.²

1	11	Ears.....	6.75	6.00	0.61	0.55	-0.06	-11	12	14
		Stalks.....	12.75	10.25	1.16	.93	-.23	-20	21	27
2	21	Ears.....	10.25	13.25	.49	.63	.14	29	17	17
		Stalks.....	15.75	23.75	.75	1.13	.38	51	13	17
3	12	Ears.....	8.00	9.00	.67	.75	.08	13	17	17
		Stalks.....	12.00	13.50	1.00	1.13	.13	13	0	17
4	16	Ears.....	8.25	8.25	.52	.52	.00	0	25	25
		Stalks.....	13.75	13.50	.86	.84	-.02	-2	14	18
5	19	Ears.....	11.25	11.50	.59	.61	.02	2	25	25
		Stalks.....	19.50	17.75	1.03	.93	-.10	-9	4	14
6	13	Ears.....	7.00	7.25	.54	.56	.02	4	21	23
		Stalks.....	13.00	12.25	1.00	.94	-.06	-6	18	23
7	17	Ears.....	9.75	11.50	.57	.68	.11	18	21	23
		Stalks.....	15.00	17.50	.88	1.03	.15	17	25	22
8	22	Ears.....	12.00	10.50	.55	.48	-.07	-13	25	22
		Stalks.....	20.00	20.00	.91	.91	.00	0	7	9
9	7	Ears.....	4.00	4.25	.57	.61	.04	6	20	21
		Stalks.....	7.25	6.50	1.04	.93	-.11	-10	9	20
10	18	Ears.....	11.00	10.00	.61	.56	-.05	-9	20	21
		Stalks.....	17.00	15.50	.94	.86	-.08	-9	20	21

¹ Favoring the cross: Ears, 3 out of 10; stalks, 3 out of 10. Average weight of ears per stalk produced by the female parent, 0.56 pound; by the cross, 0.61 pound. Average weight of stover per stalk produced by female parent, 0.88 pound; by the cross, 0.80 pound. Increased yield of cross over the female parent: Grain, -8 per cent; stover, -9 per cent.

² Favoring the cross: Ears, 6 out of 10; stalks, 3 out of 10. Average weight of ears per stalk produced by the female parent, 0.57 pound; by the cross, 0.59 pound. Average weight of stover per stalk produced by female parent, 0.94 pound; by the cross, 0.96 pound. Increased yield of cross over the female parent: Grain, 4 per cent; stover, 3 per cent.

TABLE XVI.—Yield record of 11 varieties of corn and their crossed progeny tested at Statesboro, Ga.—Continued.

SANDERS PROLIFIC ♀ × RODGERS WHITE DENT ♂¹

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds).					Per cent of difference.	Number of ears produced.	
			Total.		Per stalk.				Original.	Cross.
			Original.	Cross.	Original.	Cross.	Difference.			
1	10	Ears.....	4.75	5.00	0.48	0.50	0.02	5	10	11
		Stalks.....	6.75	7.25	.68	.73	.05	7		
2	20	Ears.....	9.50	11.50	.48	.58	.10	21	21	23
		Stalks.....	14.50	18.00	.73	.90	.17	24		
3	15	Ears.....	7.50	10.25	.50	.68	.18	37	16	19
		Stalks.....	12.25	16.00	.82	1.07	.26	31		
4	18	Ears.....	9.75	10.50	.54	.58	.04	8	19	21
		Stalks.....	14.75	18.00	.82	1.00	.18	22		
5	4	Ears.....	2.50	2.25	.63	.56	— .07	— 10	5	4
		Stalks.....	5.00	3.50	1.26	.88	— .37	— 30		
6	20	Ears.....	10.00	12.50	.50	.63	.13	25	21	23
		Stalks.....	15.00	20.00	.75	1.00	.25	33		
7	15	Ears.....	8.25	8.25	.55	.55	.00	0	20	16
		Stalks.....	11.25	12.25	.75	.82	.07	9		
8	18	Ears.....	10.25	10.25	.57	.57	.00	0	21	21
		Stalks.....	15.00	14.75	.83	.82	— .01	— 2		
9	21	Ears.....	9.50	10.75	.45	.51	.06	13	22	25
		Stalks.....	14.25	17.50	.68	.83	.15	23		
10	23	Ears.....	10.50	12.25	.46	.53	.07	17	24	23
		Stalks.....	16.00	19.25	.70	.84	.14	20		

STATION YELLOW ♀ × MARLBORO PROLIFIC ♂²

1	19	Ears.....	9.25	13.75	0.49	0.72	0.23	49	20	31
		Stalks.....	15.50	20.50	.82	1.08	.26	32	.....	.....
2	21	Ears.....	10.25	10.25	.49	.49	.00	0	23	23
		Stalks.....	17.00	16.00	.81	.76	-.05	-6	.....	.....
3	15	Ears.....	8.50	7.75	.57	.52	-.05	-9	19	18
		Stalks.....	14.50	11.75	.97	.78	-.19	-19	.....	.....
4	17	Ears.....	8.25	8.00	.49	.47	-.02	-3	18	23
		Stalks.....	13.00	12.50	.76	.74	-.02	-4	.....	.....
5	19	Ears.....	8.75	10.50	.46	.55	.09	20	19	23
		Stalks.....	13.00	17.25	.68	.91	.23	33	.....	.....
6	19	Ears.....	9.00	10.00	.47	.53	.06	11	20	21
		Stalks.....	14.50	15.00	.76	.79	.03	3	.....	.....
7	12	Ears.....	5.50	6.00	.46	.50	.04	9	12	15
		Stalks.....	8.75	11.00	.73	.92	.19	26	.....	.....
8	18	Ears.....	10.00	9.75	.56	.54	-.02	-3	18	18
		Stalks.....	15.25	15.00	.85	.83	-.02	-2	.....	.....
9	15	Ears.....	7.50	10.75	.50	.72	.22	43	15	24
		Stalks.....	11.50	15.75	.77	1.05	.28	37	.....	.....
10	19	Ears.....	10.00	10.50	.53	.55	.02	5	25	23
		Stalks.....	14.75	16.50	.78	.87	.09	12	.....	.....

¹ Favoring the cross: Ears, 7 out of 10; stalks, 8 out of 10. Average weight of ears per stalk produced by the female parent, 0.50 pound; by the cross, 0.57 pound. Average weight of stover per stalk produced by female parent, 0.76 pound; by the cross, 0.89 pound. Increased yield of cross over the female parent: Grain, 13 per cent; stover, 17 per cent.

² Favoring the cross: Ears, 6 out of 10; stalks, 6 out of 10. Average weight of ears per stalk produced by the female parent, 0.50 pound; by the cross, 0.56 pound. Average weight of stover per stalk produced by female parent, 0.79 pound; by the cross, 0.87 pound. Increased yield of cross over the female parent: Grain, 12 per cent; stover, 10 per cent.

TABLE XVI.—Yield record of 11 varieties of corn and their crossed progeny tested at Statesboro, Ga.—Continued.

STATION YELLOW ♀ × RODGERS WHITE DENT ♂.¹

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds).					Per cent of difference.	Number of ears produced.	
			Total.		Per stalk.				Original.	Cross.
			Original.	Cross.	Original.	Cross.	Difference.			
1	16	Ears.....	8.25	8.75	0.52	0.55	0.03	6	17	17
		Stalks.....	13.00	14.00	.81	.88	.07	8		
2	22	Ears.....	11.75	15.75	.53	.72	.19	34	24	24
		Stalks.....	20.00	26.50	.91	1.20	.29	33		
3	18	Ears.....	11.00	10.50	.61	.58	-.03	5	20	19
		Stalks.....	19.25	19.50	1.07	1.08	.01	1		
4	19	Ears.....	10.00	11.00	.53	.58	.05	10	23	19
		Stalks.....	16.50	18.25	.87	.96	.09	11		
5	22	Ears.....	9.50	13.25	.43	.60	.17	39	22	26
		Stalks.....	14.00	19.75	.64	.90	.26	41		
6	19	Ears.....	11.25	12.25	.59	.64	.05	9	26	21
		Stalks.....	19.00	19.50	1.00	1.03	.03	3		
7	16	Ears.....	8.75	8.75	.55	.55	.00	0	16	16
		Stalks.....	15.00	16.00	.94	1.00	.06	7		
8	21	Ears.....	11.75	13.50	.56	.64	.08	15	21	21
		Stalks.....	19.25	21.00	.92	1.00	.08	9		
9	20	Ears.....	8.50	10.75	.43	.54	.11	26	20	21
		Stalks.....	13.00	17.50	.65	.88	.23	35		
10	18	Ears.....	8.50	7.75	.47	.43	-.04	9	20	19
		Stalks.....	13.75	12.25	.76	.68	-.08	11		

TENDAL ♀ × MARLBORO PROLIFIC ♂.²

1	22	Ears.....	11.75	12.00	0.53	0.55	0.02	2	30	34
		Stalks.....	17.50	18.75	.80	.85	.05	7	.....	.....
2	19	Ears.....	9.50	9.50	.50	.50	.00	0	27	26
		Stalks.....	14.50	14.75	.76	.78	.02	2	.....	.....
3	23	Ears.....	12.00	12.00	.52	.52	.00	0	33	32
		Stalks.....	18.00	18.75	.78	.82	.04	4	.....	.....
4	21	Ears.....	11.00	12.25	.52	.58	.06	11	30	33
		Stalks.....	17.75	19.25	.85	.92	.07	8	.....	.....
5	18	Ears.....	9.50	8.25	.53	.46	-.07	13	26	23
		Stalks.....	16.25	13.50	.90	.75	-.15	17	.....	.....
6	15	Ears.....	7.50	7.50	.50	.50	.00	0	19	16
		Stalks.....	12.50	12.00	.83	.80	-.03	4	.....	.....
7	24	Ears.....	15.00	11.25	.63	.47	-.16	25	37	26
		Stalks.....	23.75	18.00	.99	.75	-.24	24	.....	.....
8	17	Ears.....	9.00	9.75	.53	.57	.04	8	21	21
		Stalks.....	14.00	15.00	.82	.88	.06	7	.....	.....
9	18	Ears.....	9.00	8.75	.50	.49	-.01	3	19	19
		Stalks.....	13.50	13.50	.75	.75	.00	0	.....	.....
10	24	Ears.....	12.00	12.25	.50	.51	.01	2	33	26
		Stalks.....	18.00	18.75	.75	.78	.03	4	.....	.....

¹ Favoring the cross: Ears, 7 out of 10; stalks, 9 out of 10. Average weight of ears per stalk produced by the female parent, 0.52 pound; by the cross, 0.59 pound. Average weight of stover per stalk produced by female parent, 0.85 pound; by the cross, 0.96 pound. Increased yield of cross over the female parent: Grain, 13 per cent; stover, 13 per cent.

² Favoring the cross: Ears, 4 out of 10; stalks, 6 out of 10. Average weight of ears per stalk produced by the female parent, 0.53 pound; by the cross, 0.51 pound. Average weight of stover per stalk produced by female parent, 0.82 pound; by the cross, 0.81 pound. Increased yield of cross over the female parent: Grain, -3 per cent; stover, -2 per cent.

TABLE XVI.—Yield record of 11 varieties of corn and their crossed progeny tested at Statesboro, Ga.—Continued.

TINDAL ♀ × RODGERS WHITE DENT ♂¹

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds).					Per cent of difference.	Number of ears produced.	
			Total.		Per stalk.				Original.	Cross.
			Original.	Cross.	Original.	Cross.	Difference.			
1	12	Ears.....	6.00	5.75	0.50	0.48	-0.02	- 4	18	14
		Stalks.....	9.25	9.25	.77	.77	.00	0	.....	.....
2	20	Ears.....	9.50	10.75	.48	.54	.06	13	26	22
		Stalks.....	15.75	17.25	.79	.86	.07	10	.....	.....
3	24	Ears.....	10.25	12.25	.43	.51	.06	20	29	28
		Stalks.....	15.00	19.50	.63	.81	.18	30	.....	.....
4	20	Ears.....	9.75	10.50	.49	.53	.04	8	26	22
		Stalks.....	15.25	16.00	.76	.80	.04	5	.....	.....
5	16	Ears.....	7.50	8.00	.47	.50	.03	7	17	18
		Stalks.....	11.75	12.25	.73	.77	.04	4	.....	.....
6	23	Ears.....	11.50	14.00	.60	.61	.11	22	27	32
		Stalks.....	18.75	21.00	.82	.91	.09	12	.....	.....
7	16	Ears.....	9.25	8.00	.58	.50	- .08	-14	22	16
		Stalks.....	14.00	13.00	.88	.81	- .07	- 7	.....	.....
8	13	Ears.....	7.00	7.50	.54	.58	.04	7	14	13
		Stalks.....	10.50	11.25	.81	.87	.06	7	.....	.....
9	13	Ears.....	6.50	7.75	.60	.60	.10	19	15	14
		Stalks.....	10.25	10.50	.79	.81	.02	2	.....	.....
10	18	Ears.....	10.00	9.25	.56	.51	- .05	- 8	25	22
		Stalks.....	14.25	14.75	.79	.82	.03	4	.....	.....

WHELCHER ♀ × MARLBORO PROLIFIC ♂²

1	9	Ears.....	4.25	5.25	0.47	0.58	0.11	24	9	9
		Stalks.....	8.00	9.50	.89	1.06	.17	19	.....	.....
2	8	Ears.....	5.00	4.00	.63	.50	-.13	-20	9	10
		Stalks.....	8.75	8.25	1.09	1.03	-.06	-6	.....	.....
3	7	Ears.....	4.75	4.25	.68	.61	-.07	-10	8	7
		Stalks.....	8.25	7.50	1.18	1.07	-.11	-9	.....	.....
4	24	Ears.....	15.75	15.75	.66	.66	.00	0	26	29
		Stalks.....	26.75	27.75	1.11	1.16	.05	4	.....	.....
5	17	Ears.....	9.75	10.75	.57	.63	.06	10	17	17
		Stalks.....	16.00	19.00	.94	1.12	.18	19	.....	.....
6	20	Ears.....	12.50	14.75	.63	.74	.11	18	21	26
		Stalks.....	25.00	25.50	1.25	1.28	.03	2	.....	.....
7	12	Ears.....	9.00	7.75	.75	.65	-.10	-14	12	12
		Stalks.....	16.00	13.00	1.33	1.08	-.25	-19	.....	.....
8	6	Ears.....	4.50	5.00	.75	.83	.08	11	7	9
		Stalks.....	8.00	7.75	1.33	1.29	-.04	-3	.....	.....
9	18	Ears.....	11.75	14.00	.65	.78	.13	19	19	23
		Stalks.....	20.75	23.75	1.15	1.32	.17	14	.....	.....
10	22	Ears.....	15.50	16.50	.70	.75	.05	6	22	29
		Stalks.....	27.50	27.50	1.25	1.25	.00	0	.....	.....

¹ Favoring the cross: Ears, 7 out of 10; stalks, 8 out of 10. Average weight of ears per stalk produced by the female parent, 0.50 pound; by the cross, 0.54 pound. Average weight of stover per stalk produced by female parent, 0.77 pound; by the cross, 0.83 pound. Increased yield of cross over the female parent: Grain, 7 per cent; stover, 7 per cent.

² Favoring the cross: Ears, 6 out of 10; stalks, 5 out of 10. Average weight of ears per stalk produced by the female parent, 0.65 pound; by the cross, 0.69 pound. Average weight of stover per stalk produced by female parent, 1.15 pounds; by the cross, 1.19 pounds. Increased yield of cross over the female parent: Grain, 6 per cent; stover, 3 per cent.

TABLE XVI.—*Yield record of 11 varieties of corn and their crossed progeny tested at Statesboro, Ga.—Continued.*WILLIAMSON ♀ × MARLBORO PROLIFIC ♂¹

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds).					Per cent of difference.	Number of ears produced.	
			Total.		Per stalk.				Original.	Cross.
			Original.	Cross.	Original.	Cross.	Difference.			
1	11	Ears.....	4.50	5.00	0.41	0.45	0.04	11	11	11
		Stalks.....	7.00	8.50	.64	.77	.13	21		
2	14	Ears.....	6.50	9.00	.46	.64	.18	38	16	18
		Stalks.....	11.75	13.75	.84	.98	.14	17		
3	13	Ears.....	7.25	7.00	.56	.54	-.02	-3	13	15
		Stalks.....	11.75	11.50	.90	.88	-.02	-2		
4	13	Ears.....	6.25	6.50	.48	.50	.02	4	14	15
		Stalks.....	10.25	9.75	.79	.75	-.04	-5		
5	17	Ears.....	6.50	10.00	.38	.59	.21	54	17	19
		Stalks.....	10.50	17.25	.62	1.01	.39	64		
6	17	Ears.....	8.50	8.50	.50	.50	.00	0	18	17
		Stalks.....	13.00	13.00	.76	.76	.00	0		

WILLIAMSON ♀ × RODGERS WHITE DENT ♂²

1	18	Ears.....	8.50	9.50	0.47	0.53	0.06	12	19	21
		Stalks.....	15.50	17.50	.86	.97	.11	13		
2	22	Ears.....	10.75	14.75	.49	.67	.18	37	22	28
		Stalks.....	18.50	25.75	.84	1.17	.33	39		
3	18	Ears.....	10.50	11.00	.58	.61	.03	5	19	20
		Stalks.....	16.75	17.50	.93	.97	.04	4		
4	23	Ears.....	11.50	14.50	.50	.63	.13	26	20	22
		Stalks.....	20.25	26.00	.88	1.13	.25	28		
5	14	Ears.....	6.75	7.50	.48	.54	.06	11	14	15
		Stalks.....	11.25	12.50	.80	.89	.09	11		
6	16	Ears.....	7.00	9.00	.44	.56	.12	29	16	16
		Stalks.....	11.75	15.50	.73	.97	.24	32		
7	6	Ears.....	3.75	3.25	.63	.54	-.09	-13	7	6
		Stalks.....	6.75	5.50	1.13	.92	-.21	-19		
8	8	Ears.....	4.25	5.00	.53	.63	.10	18	9	8
		Stalks.....	6.75	8.25	.84	1.03	.19	22		
9	15	Ears.....	7.75	8.00	.52	.53	.01	3	16	15
		Stalks.....	13.00	13.00	.87	.87	.00	0		
10	15	Ears.....	7.50	6.75	.50	.45	-.05	10	15	15
		Stalks.....	12.00	12.00	.80	.80	.00	0		

¹ Favoring the cross: Ears, 4 out of 6; stalks, 3 out of 6. Average weight of ears per stalk produced by the female parent, 0.46 pound; by the cross, 0.54 pound. Average weight of stover per stalk produced by female parent, 0.76 pound; by the cross, 0.87 pound. Increased yield of cross over the female parent: Grain, 16 per cent; stover, 14 per cent.

² Favoring the cross: Ears, 8 out of 10; stalks, 7 out of 10. Average weight of ears per stalk produced by the female parent, 0.50 pound; by the cross, 0.53 pound. Average weight of stover per stalk produced by female parent, 0.85 pound; by the cross, 0.99 pound. Increased yield of cross over the female parent: Grain, 14 per cent; stover, 16 per cent.

In Table XVII a comparison of the effect of crossing is made between the varieties as a whole, when crossed by Marlboro Prolific and when crossed by Rodgers White Dent. The percentage of increase or decrease in yield of the cross is given, and also the number of rows out of 10 in which the production of the crossed ears was greater than that of the original 2-year-old seed of the female parent grown in the same hills with the cross.

TABLE XVII.—*Summary of the 10 ears of each variety tested with their crossed progeny.*

Female variety.	Marlboro Prolific sire.				Rodgers White Dent sire.			
	Increase of cross over 1908 seed of female parent.		Rows favoring the cross.		Increase of cross over 1908 seed of female parent.		Rows favoring the cross.	
	Ears.	Stalks.	Ears.	Stalks.	Ears.	Stalks.	Ears.	Stalks.
	Percent.	Per cent.			Percent.	Per cent.		
Aldrich Perfection.....	12	- 6	6	5	10	15	7	9
Cocke Prolific.....	8	2	7	4	2	- 2	7	5
Marlboro Prolific.....	3	2	6	5	7	8	7	8
Mosby Prolific.....	13	6	10	6	28	19	10	10
Native of Statesboro.....	6	6	6	7	7	5	6	4
Rodgers White Dent.....	10	12	7	10	- 8	- 9	3	3
Sanders Prolific.....	4	3	6	3	13	17	7	8
Station Yellow.....	12	10	6	6	13	13	7	9
Tindal.....	- 3	- 2	4	6	7	7	7	8
Williamson.....	16	14	14	13	14	16	8	7
General results.....	7	4	6.9	6.1	9	9	6.9	7

¹ Only six rows considered.

Table XVII shows that when crossed with Marlboro Prolific all but one variety (Tindal) gave a gain in ears, and all but two varieties gave a gain in stover. When crossed with Rodgers White Dent all varieties except the sire variety itself gave a gain in ears, and only two gave a loss in stover.

SOME CROSSES SUPERIOR TO EITHER PARENT.

Since the yields of the crosses are compared only with the female parent, it might be concluded that this general higher yield of the crosses is probably due to the still greater productiveness of the male parent. This conclusion, however, is not supported in the cases where Marlboro Prolific and Rodgers White Dent serve as females in the experiment. In both instances the resulting cross produced better than its female parent and since Rodgers White Dent is more productive than Marlboro Prolific, as shown in Table XVII, the cross in which Rodgers White Dent served as female must be considered more productive than either parent.

In Table XVIII is shown the average ranking of the varieties according to their productiveness in 1910 in the test plats at Statesboro, Ga., where each variety was grown in the same hills with its crossed progeny.

TABLE XVIII.—*Arrangement of varieties of corn in the order of their productiveness, as indicated by the average yield per stalk when grown in hills with their crosses.*

Name of variety.	Ears per stalk.	Average rank.	Name of variety.	Ears per stalk.	Average rank.
	<i>Pounds.</i>			<i>Pounds.</i>	
Sanders Prolific.....	0.535	1	Native of Statesboro.....	0.51	4b
Aldrich Perfection.....	.53	2a	Station Yellow.....	.51	4c
Rodgers White Dent.....	.53	2b	Cocke Prolific.....	.49	5
Tindal.....	.515	3	Williamson.....	.48	6
Marlboro Prolific.....	.51	4a	Mosby Prolific.....	.465	7

It will be seen that seven varieties equal or excel Marlboro Prolific. When these seven varieties are crossed with Marlboro Prolific as sire six out of the seven first-generation crosses exceed the Marlboro Prolific in grain production, and five in stover production.

It will also be seen that two varieties equal or excel Rodgers White Dent. When these two varieties are crossed with Rodgers White Dent as sire both of the first-generation crosses exceed the Rodgers White Dent in grain and stover production. It will thus be seen that out of the 20 crosses made 8 have given grain yields greater than the better parent, and 7 have given stover yields greater than the better parent.

RELATION OF THE PRODUCTIVITY OF THE CROSSES TO THE PRODUCTIVITY OF THE PURE STRAINS.

It is a striking point in connection with the foregoing table that all those female varieties giving more productive crosses than either parent are grouped at one end—the upper end—of the ranking list for production and with but one break in the rank. None fall below fourth in production in a total ranking of seven. With one exception the varieties that can not be said to have given advantageous crosses with either sire are grouped at the other or lower end of the ranking list.

Omitting Marlboro Prolific and Rodgers White Dent, nine other varieties are crossed by each of these sires. In six out of the nine comparisons the crosses with Rodgers White Dent are more productive than those with Marlboro Prolific.

In view of these points and the fact that Rodgers White Dent is more productive than Marlboro Prolific it is found that the productiveness of both parents seems to stand out clearly as a factor in influencing high yield in first-generation crosses.

The Tindal variety, however, is a striking exception to this seeming tendency. The rank of this variety is third in productiveness, but when crossed by Marlboro Prolific its yield was actually less than its poorest producing parent; and when crossed by Rodgers White Dent the cross was less productive than that sire.

Because of this exception, this apparent tendency can not be relied upon as a guide in the selection of suitable varieties for practical crossing.

ADAPTATION AS A FACTOR IN THE PRODUCTION OF HIGHER YIELDS THROUGH CROSSING.

As the difference between the lowest and the highest producers is less than 5 bushels per acre, it would seem that it might be questionable to discuss this subject with the data at hand. In justice to the subject, however, it should be stated that the appearance of the corn produced indicated more variability in adaptation than do the weights.

It is interesting to note in this connection that the variety Mosby Prolific is farthest from home, that it has been carried to a more radically different soil than any of the other varieties, and that it is ranked lowest in yield and failed to give a practical cross. Cocke Prolific is the next farthest from home, ranks third from the bottom of the list, and was impractical for crossing with either Marlboro Prolific or Rodgers White Dent. The Williamson corn ranks next to Mosby Prolific; as it had been given considerable selection at home for years, it is reasonable to suppose that its low yield is due to poor adaptation.

It is thus seen that three out of the four varieties that were impractical as crosses with either of the two sires were also poorly adapted to the conditions at Statesboro. The Tindal variety again stands out as an exception.

INFLUENCE OF SEASONAL DIFFERENCES.

In 1909, while the crosses for this test were being grown, a careful comparison of the varieties was made. The season was different from that of 1910, and the effect is clearly shown by the ranking obtained at that time.

The ranking for 1909 was:

First	Tindal.	Sixth	Williamson.
Second	Station Yellow.	Seventh	Mosby Prolific.
Third	Native of Statesboro.	Eighth	Aldrich Perfection.
Fourth	Rodgers White Dent.	Ninth	Cocke Prolific.
Fifth	Marlboro Prolific.	Tenth	Sanders Prolific.

Apparently the difference between the two seasons has resulted in changing Sanders Prolific from last to first in rank and Aldrich Perfection from eighth to second. The first year less difference in production was shown between the two sire varieties than was shown the second year. In 1909 Mosby Prolific (poorest in 1910) ranked better than Aldrich Perfection (second in 1910). Tindal ranked high both years.

The differences shown by the two tests are radical, but hardly more than is frequently found in variety tests of more than one year.

If, as has been previously indicated, there is usually a relation between high yield and adaptation and the advantageous crossing of corn, then it would seem that seasonal differences may play an important part.

INFERENCES DRAWN FROM THE FOREGOING DATA.

From these tests it would seem that the productivity of first-generation crosses is usually correlated to the productivity of the parent varieties, and the yield of the parent varieties is largely dependent upon their adaptation to the location and the season during which the test is made.

As seasonal differences have a marked effect upon the comparative production of varieties the success of a cross one season may be found fleeting if continued.

The fact that the variety Tindal in its adverse performance toward crossing has rather emphatically ignored all the influences of rank and adaptation that seem to govern other varieties may indicate that advantageous exceptions may also be found; but whatever further investigation may demonstrate, present knowledge indicates that the economic increasing of corn yields by means of crossing is attended with many complexities.

GENERAL CONSIDERATION OF ALL THE TESTS.

INDICATIONS OF INTERMEDIACY.

As the varieties crossbred at the various points are varieties that have met with general favor as grain producers, the characters of the male and female parents of each cross are not radically different, and consequently any intermediacy of a cross is not as apparent as it might be if the parents were much unlike. However, in many instances intermediacy between the two parents was observed regarding various characters; such as productiveness, height of stalk, length of growing season, and percentage of moisture.

Averages of many crosses usually indicate intermediacy, because exceptions in one direction from the median points are offset by exceptions in the other direction, but under the conditions of these and other tests of this nature so few instances have been shown in which the first-generation crosses produced less than the average of the two parents as to indicate that the average productiveness of first-generation corn crosses is usually above the average of the parents. It may be that this indication will not be found entirely due to advantages regarding adaptation, age of seed, self-fertilization, etc., that most of the reported tests ¹ have given to the first-generation

¹ Beal, W. J. Reports, Michigan Board of Agriculture, 1876, 1877, 1881, and 1882.

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crosses, and that further work with all conditions more nearly equalized will demonstrate a general tendency for first-generation crosses to produce better than the average of the parents. Such a general tendency might be due to prepotency of the higher yielding parent. It is more profitable to grow the higher yielding parent except in cases in which the first-generation cross produces better than either parent. Since some first-generation crosses are more productive and some are less productive than their better parent, the greatest benefit can be obtained by planting such as may be found more productive than the highest yielding variety of a community.

**PERCENTAGE OF MOISTURE IN SHELLED GRAIN OF CROSSES AND
PARENT VARIETIES.**

Because of care in allowing the ears of all varieties to dry thoroughly before yields were weighed it has not been necessary to calculate corrections for moisture content except in the Maryland tests. The moisture content of shelled grain from a large number of ears of each variety at each point was determined by the Office of Grain Standardization of the Bureau of Plant Industry. Regarding this character, averages as given in Table XIX show the first-generation crosses to be intermediate between the parents.

TABLE XIX.—Average percentage of moisture in shelled grain of crosses and parent varieties on dates when yields were weighed.

Tests.	Female parents.	Male parents.	Average of both parents.	First-gen- eration crosses.
Maryland.....	27.29	28.77	28.03	28.32
California.....	10.22	11.74	10.98	10.90
Texas.....	12.39	11.45	11.92	12.13
Georgia.....	15.40	15.01	15.21	15.00
General average.....	16.33	16.74	16.54	16.59

UNRELIABILITY OF AVERAGES FOR SPECIFIC INSTANCES.

With investigations of this nature the investigators as well as the readers are desirous that the work should discover some law of nature. However, the development and evolution of plants furnish so many exceptions and variations to even general laws that it is impossible to foretell the effects of crossbreeding particular varieties by the effects secured previously from crossbreeding other varieties. Types, varieties, strains, ears, and even kernels of corn contain in their lineage such complexity of structure and characters that it is not surprising that this work, necessarily of a preliminary nature, should unfold more problems than it solves.

The results are interesting because they contain evidence in support of various theories, but the chief value of the work is its indi-

cation of what can be accomplished in the field of research and more especially in establishing methods of producing high-yielding seed corn.

The influences that show with the greatest uniformity in these tests are those of acclimatization and adaptation. The results given here of these influences will be combined in a future publication with results obtained in other localities showing the effects on maize of acclimatization and adaptation. In studying the effects attributable to crossbreeding it is necessary to recognize the effects due both to acclimatization and to adaptation. The distinction between the effects of acclimatization and of adaptation is brought out in the tests of identically the same lots of seed in Maryland and in California. In Maryland, because of their acclimatization and adaptation some varieties produced much better than others of the same growing period which were brought from distant States. None of these varieties were acclimated to California conditions, though some of the earliest maturing, which were least productive in Maryland, were most productive in California. Their early maturity proved an adaptation which enabled them to escape the later and drier part of the summer. In Texas, varieties that have been subjected for years to practically the same climatic conditions indicate different degrees of adaptation to clay soils and to sandy soils.

Tests of this nature thus far reported indicate that first-generation crosses usually produce better than the average of the two parents. It is not certain that this is entirely due to the advantages that these tests have given to the crosses regarding age and vitality of seed, or to the year of adaptation and selection incident to growing the crossbred seed under the same environment in which the test of productiveness was afterwards made, but to which the parent varieties were not adapted. If further tests should show that with all conditions equalized there still exists a tendency for first-generation crosses to produce better than the average of the two parents, it might be taken as an indication that the higher yielding parent is usually prepotent.

A production better than the average of the two parents, unless it be better than the production of either parent, would furnish no practical method of originating strains superior to those already existing, except in cases in which the crossing might originate strains that combine or nick better than previously existing strains. When all influencing factors, such as age and maturity of seed, acclimatization, and adaptation are equal, and the first-generation cross is more productive than either parent, it is a clear instance in which a practical advantage is derived by crossbreeding.

Variations found to apply to varieties are also found to apply to different ears within a variety when they are crossbred and tested separately—in other words, some ears are crossed with another

variety advantageously and some disadvantageously, though in general there is a tendency for the different ears of a variety to respond similarly to the crossing. Another line of work being conducted by the Office of Corn Investigations indicates that what has just been said about the crossing of one variety with another also applies to the crossbreeding of individual plants within a variety. Just as certain pairs of varieties combine or nick advantageously, while other pairs nick disadvantageously, so some pairs of individual plants nick advantageously, while other pairs nick disadvantageously. This shows the results obtained by crossing two varieties without reference to individual plants to be but an average of the results that would be obtained by crossing many individual plants of those varieties. The average results may be an improvement over either parent and still fall short of what could be obtained by restricting the crossing to the individuals that nick most advantageously.

In connection with this consideration of crossbreeding, it is interesting to note that such varieties as Selection 119, Selection 160, and Chisholm, which are among the most profitable varieties for their respective localities, have not been crossbred or mixed with other varieties for many years. The same can be said of leading strains of corn of other localities, and their merits are doubtless largely due to effects of selection, acclimatization, and adaptation.

The results of these tests show that with corn some first-generation crosses are more productive than either parent, that some are intermediate between the two parents in productiveness, and that some are less productive than either parent. They also show that the determination of the particular first-generation crosses that can be most profitably grown is attended with so many complexities that careful tests must be made in a locality before the farmers of that locality can be intelligently advised whether it is to their interest to continue planting a pure-bred strain, or to plant a first-generation cross of certain strains.

In crossbreeding corn for practical results it seems the duty of State experiment stations and of corn breeders to determine what two varieties nick to best advantage in producing seed for different environments. Whether the yearly production of a particular first-generation cross will be found advisable, or whether its use in making other crosses will be found more profitable, must be established by further work, and perhaps for each individual case. Progress in producing higher yielding strains of corn depends upon the proper combination and application of the effects of acclimatization, adaptation, crossbreeding, and selection.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 219.

B. T. GALLOWAY, *Chief of Bureau.*

AMERICAN MEDICINAL LEAVES AND HERBS.

BY

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., April 15, 1911.

SIR: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 219 of the series of this Bureau the accompanying manuscript, entitled "American Medicinal Leaves and Herbs." This paper was prepared by Miss Alice Henkel, Assistant in Drug-Plant Investigations, and has been submitted by the Physiologist in charge with a view to its publication.

Thirty-six plants furnishing leaves and herbs for medicinal use are fully described, and in some instances brief descriptions of related species are included therewith. Of the above number, 15 are official in the United States Pharmacopœia.

This bulletin forms the third installment on the subject of American medicinal plants and has been prepared to meet the steady demand for information of this character. It is intended as a guide and reference book for those who may be interested in the study or collection of the medicinal plants of this country. The first bulletin of this series treats of American root drugs, and the second of American medicinal barks.

Respectfully,

WM. A. TAYLOR,
Acting Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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AMERICAN MEDICINAL LEAVES AND HERBS.

INTRODUCTION.

Less difficulty will be encountered in the collection of leaves and herbs than in the case of other portions of plants, for not only is recognition easier, since, especially in the matter of herbs, these parts are usually gathered at a time when the plants are in flower, but the labor is less arduous, for there are no roots to dig or barks to peel.

Of the three dozen medicinal plants mentioned in this bulletin, 15 are recognized as official in the Eighth Decennial Revision of the United States Pharmacopœia. This is more than half of all the leaves and herbs included in the Pharmacopœia.

Among the plants included in this bulletin are peppermint and spearmint, which are found not only in the wild state but the cultivation of which for the distillation of the oil constitutes an important American industry. Especially is this true of peppermint, thousands of acres being devoted to the cultivation of this plant, principally in the States of Michigan and New York. A number of other plants mentioned in this paper furnish useful oils, such as oil of wintergreen, pennyroyal, fleabane, tansy, wormwood, and fireweed.

As in the case of other bulletins of this series, an effort has been made to include in it only such plants as seem most in demand, lack of space forbidding a consideration of others which are or have been used to a more limited extent. With two or three exceptions the illustrations have been reproduced from photographs taken from nature by Mr. C. L. Lochman.

COLLECTION OF LEAVES AND HERBS.

Leaves are usually collected when they have attained full development and may be obtained by cutting off the entire plant and stripping the leaves from the stem, using a scythe to mow the plants where they occur in sufficient abundance to warrant this, or the leaves may be picked from the plants as they grow in the field. Whenever the plants are cut down in quantity they must be carefully looked over afterwards for the purpose of sorting out such

other plants as may have been accidentally cut with them. Stems should be discarded as much as possible, and where a leaf is composed of several leaflets these are usually detached from the stems.

In gathering herbs only the flowering tops and leaves and the more tender stems should be taken, the coarse and large stems being rejected. All withered, diseased, or discolored portions should be removed from both leaves and herbs.

In order that they may retain their bright-green color and characteristic odor after drying, leaves and herbs must be carefully dried in the shade, allowing the air to circulate freely but keeping out all moisture; dampness will darken them, and they must therefore be placed under cover at night or in rainy weather. A bright color is desirable, as such a product will sell more readily.

To dry them the leaves and herbs should be spread out thinly on clean racks or shelves and turned frequently until thoroughly dry. They readily absorb moisture and when perfectly cured should be stored in a dry place.

Leaves and herbs generally become very brittle when they are dry and must be very carefully packed to cause as little crushing as possible. They should be firmly packed in sound burlap or gunny sacks or in dry, clean boxes or barrels. Before shipping the goods, however, good-sized representative samples of the leaves and herbs to be disposed of should be sent to drug dealers for their inspection, together with a letter stating how large a quantity the collector has to sell.

With the changes in prices that are constantly taking place in the drug market it is, of course, impossible to give definite prices in this paper, and only approximate quotations are therefore included in order that the collector may form some idea concerning the possible range of prices. Only through correspondence with drug dealers can the actual price then prevailing be ascertained.

PLANTS FURNISHING MEDICINAL LEAVES AND HERBS.

Each section contains synonyms, the pharmacopœial name (if any), the common names, habitat, range, descriptions, and information concerning the collection, prices, and uses of the plants.

The medicinal uses are referred to in a general way only, since it is not within the province of a publication of this kind to give detailed information in regard to such matters. Advice concerning the proper remedies to use should be sought only from physicians. The statements made in this paper as to medicinal uses are based on information contained in various dispensaries and other works relating to *materia medica*.

SWEET FERN.

Comptonia peregrina (L.) Coulter.

Synonyms.—*Comptonia asplenifolia* Gaertn.; *Myrica asplenifolia* L.; *Liquidambar asplenifolia* L.; *Liquidambar peregrina* L.

Other common names.—Fern gale, fern bush, meadow fern, shrubby fern, Canada sweet gale, spleenwort bush, sweet bush, sweet ferry.

Habitat and range.—Sweet fern is usually found on hillsides, in dry soil, in Canada and the northeastern United States. It is indigenous.

Description.—The fragrant odor and the resemblance of the leaves of this plant to those of a fern have given rise to the common name "sweet fern." It is a shrub with reddish-brown bark, growing from about 1 to 3 feet in height, with slender, erect or spreading branches, the leaves hairy when young. The thin narrow leaves are borne on short stalks and are linear oblong or linear lance shaped, about 3 to 6 inches long and from one-fourth to half an inch wide, deeply divided into many lobes, the margins of which are generally entire or sparingly toothed. The catkins expand with the leaves. (Fig. 1.)

The staminate or male flowers are produced in cylindrical catkins in clusters at the ends of the branches and are about an inch in length, the kidney-shaped scales overlapping. The pistillate or female flowers are borne in egg-shaped or roundish-oval catkins, the eight awl-shaped bractlets persisting and surrounding the one-seeded, shining, light-brown nut, giving it a burlike appearance. The whole plant has a spicy, aromatic odor, which is more pronounced when the leaves are bruised. Sweet fern belongs to the bayberry family (Myricaceæ).

Collection, prices, and uses.—The entire plant is used, but especially the leaves and tops. It has a fragrant, spicy odor and an aromatic, slightly bitter, and astringent taste.

The present price of sweet fern is about 3 to 5 cents a pound.

It is used for its tonic and astringent properties, principally in a domestic way, as a remedy in diarrheal complaints.

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FIG. 1.—Sweet fern (*Comptonia peregrina*), leaves, male and female catkins.

LIVERLEAF.

(1) *Hepatica hepatica* (L.) Karst.; (2) *Hepatica acuta* (Pursh) Britton.

Synonyms.—(1) *Hepatica triloba* Chaix.; *Anemone hepatica* L. (2) *Hepatica triloba* var. *acuta* Pursh; *Hepatica acutiloba* DC.

Other common names.—(1) Round-leaved hepatica, common liverleaf, kidney liverleaf, liverwort (incorrect), noble liverwort, heart liverwort, three-leaved liverwort, liverweed, herb-trinity, golden trefoil, ivy flower, mouse-ears, squirrel cup; (2) heart liverleaf, acute-lobed liverleaf, sharp-lobed liverleaf, sharp-lobed hepatica.

Habitat and range.—The common liverleaf is found in woods from Nova Scotia to northern Florida and west to Iowa and Missouri, while the heart liverleaf occurs from Quebec to Ontario, south to Georgia (but rare near the coast), and west to Iowa and Minnesota.



FIG. 2.—Liverleaf (*Hepatica hepatica*), flowering plant.

also of a purplish color on the under surface. The flowers, which are about one-half inch in diameter, are borne singly on slender, hairy stalks arising from the root, and vary in color from bluish to purple or white. Immediately beneath the flower are three small, stemless, oval, and blunt leaflets or bracts, which are thickly covered with soft, silky hairs. (Fig. 2.)

The heart liverleaf is very similar to the common liverleaf. It grows perhaps a trifle taller and the lobes of the leaf and the small leaflets or bracts immediately under the flower are more sharply pointed.

The hepaticas are members of the crowfoot family (*Ranunculaceæ*) and are perennials. The name "liverwort," often given to these plants, is incorrect, since it belongs to an entirely different genus.

Collection, prices, and uses.—The leaves, which were official in the United States Pharmacopœia from 1830 to 1880, are the parts employed; they should be collected

in April. They lose about three-fourths of their weight in drying. The price at present paid for them is about 4 to 5 cents a pound.

Liverleaf is employed for its tonic properties and is said to be useful in affections of the liver.

CELANDINE.

Chelidonium majus L.

Other common names.—Chelidonium, garden celandine, greater celandine, tetterwort, killwart, wart flower, wartweed, wartwort, felonwort, cockfoot, devil's-milk, Jacob's ladder, swallowwort, wretweed.

Habitat and range.—Celandine, naturalized from Europe, is found in rich damp soil along fences and roadsides near towns from Maine to Ontario and southward. It is common from southern Maine to Pennsylvania.

Description.—This plant, which has rather weak, brittle stems arising from a reddish-brown, branching root, is a biennial belonging to the poppy family (Papaveraceæ) and, like other members of this family, contains an acrid juice, which in this species is colored yellow. It is an erect, branched, sparingly hairy herb, from about 1 to 2 feet in height, with thin leaves 4 to 8 inches in length. The leaves, which are lyre shaped in outline, are deeply and variously cleft, the lobes thus formed being oval, blunt, and wavy or round toothed, or rather deeply cut. They have a grayish-green appearance, especially on the lower surface. The small, 4-petaled, sulphur-yellow flowers of the celandine are produced from about April to September, followed by smooth, long, pod-shaped capsules crowned with the persistent style and stigma and containing numerous seeds. (Fig. 3.)



FIG. 3.—Celandine (*Chelidonium majus*), leaves, flowers, and seed pods.

being oval, blunt, and wavy or round toothed, or rather deeply cut. They have a grayish-green appearance, especially on the lower surface. The small, 4-petaled, sulphur-yellow flowers of the celandine are produced from about April to September, followed by smooth, long, pod-shaped capsules crowned with the persistent style and stigma and containing numerous seeds. (Fig. 3.)

Collection, prices, and uses.—The entire plant, which was official in the United States Pharmacopœia for 1890, is used. It should be collected when the herb is in flower. At present it brings about 6 or 8 cents a pound.

The fresh plant has an unpleasant, acrid odor when bruised, but in the dried state it is odorless. It has a persistent acrid and somewhat salty taste.

Celandine is an old remedy. It has cathartic and diuretic properties, promotes perspiration, and has been used as an expectorant. The juice has been employed externally for warts, corns, and some forms of skin diseases.

WITCH-HAZEL.

Hamamelis virginiana L.

Pharmacopœial name.—*Hamamelidis folia*.

Other common names.—Snapping hazel, winterbloom, wych-hazel, striped alder, spotted alder, tobacco wood.

Habitat and range.—The home of this native shrub is in low damp woods from New Brunswick to Minnesota and south to Florida and Texas.

Description.—This shrub, while it may grow to 25 feet in height, is more frequently found reaching a height of only 8 to 15 feet, its crooked stem and long forking branches

covered with smoothish brown bark, sometimes with an addition of lichens. A peculiar feature about witch-hazel is its flowering in very late fall or even early winter, when its branches are destitute of leaves, the seed forming but not ripening until the following season.

The leaves are rather large, 3 to 5 inches long, thick, and borne on short stalks; they are broadly oval or heart-shaped oval, sometimes pointed and sometimes blunt at the apex, with uneven sides at the base, and wavy margins. The older leaves are smooth, but when young they are covered with downy hairs. The upper surface of the leaves is a light-green or brownish-green color, while the lower surface is pale green and somewhat shining, with prominent veins. The threadlike bright-yellow flowers, which appear very late in autumn, are rather odd looking and consist of a 4-parted corolla with four long, narrow, strap-shaped petals, which are twisted in vari-



FIG. 4.—Witch-hazel (*Hamamelis virginiana*), leaves, flowers, and capsules.

ous ways when in full flower. The seed capsule does not mature until the following season, when the beaked and densely hairy seed case bursts open elastically, scattering with great force and to a considerable distance the large, shining-black, hard seeds. (Fig. 4.) This interesting shrub is a member of the witch-hazel family (*Hamamelidaceæ*).

Collection, prices, and uses.—Witch-hazel leaves are official in the United States Pharmacopœia. They should be collected in autumn and carefully dried. Formerly the leaves alone were recognized in the United States Pharmacopœia, but now the bark and twigs are also official. The leaves have a faint odor and an astringent, somewhat bitter, and aromatic taste. They bring about 2 to 3 cents a pound.

The soothing properties of witch-hazel were known among the Indians, and it is still employed for the relief of inflammatory conditions.

AMERICAN SENNA.

Cassia marilandica L.*Synonym.*—*Senna marilandica* Link.*Other common names.*—Wild senna, locust plant.*Habitat and range.*—American senna generally frequents wet or swampy soils from New England to North Carolina and westward to Louisiana and Nebraska.

Description.—This is a native species, a member of the senna family (Cæsalpiniaceæ), which is closely related to the pea family. It is a perennial herb, its round grooved stems reaching about 4 to 6 feet in height. The leaves, which are borne on long, somewhat bristly hairy stalks, are 6 to 8 inches long and consist of from 12 to 20 leaflets placed opposite to each other on the stem. Each leaflet is oblong or lance-shaped oblong, blunt at the top but terminating with a short, stiff point, rounded at the base and from 1 to 1½ inches long, the stalks supporting them being rather short; the upper surface is of a pale-green color, while underneath it is still lighter in color and covered with a bloom. On the upper surface of the leaf stem, near its base, is a prominent club-shaped gland, borne on a stalk.

The numerous yellow flowers are borne on slender, hairy stems, produced in clusters in the axils of the leaves at the top of the plant and appearing from about August to September. The pods are about 3 inches in length, linear,

somewhat curved and drooping, slightly hairy at first, flat, and narrowed on the sides between the seeds. They contain numerous small, flat, dark-brown seeds. (Fig. 5.)

Collection, prices, and uses.—The leaves, or rather the leaflets, are the parts employed and should be gathered at flowering time, which usually occurs during July and August. They were official in the United States Pharmacopœia from 1820 to 1880. American senna leaves have a very slight odor and a rather disagreeable taste, somewhat like that of the foreign senna. It is used for purposes similar to the well-known senna of commerce imported from abroad, having, like that, cathartic properties.

The price at present paid for American senna is about 6 to 8 cents a pound.



FIG. 5.—American senna (*Cassia marilandica*), leaves, flowers, and seed pods.

EVENING PRIMROSE.

Oenothera biennis L.*Synonyms.*—*Onagra biennis* (L.) Scop.; *Oenothera muricata* L.*Other common names.*—Common evening primrose, wild evening primrose, field evening primrose, tree primrose, fever plant, night willow-herb, king's cure-all,¹ large rampion, scurvisch, scabish.*Habitat and range.*—This is a widely distributed herb, its range extending from Labrador south to Florida and west to the Rocky Mountains. It usually frequents fields and waste places, occurring in dry soil.

FIG. 6.—Evening primrose (*Oenothera biennis*), leaves, flowers, and capsules.

Description.—The evening primrose is a coarse annual or biennial weed, which has the peculiarity that its flowers do not open until evening, remaining open all night and closing the next morning, but not expanding again. It is generally stout and erect in growth, from 1 foot to about 5 feet in height, simple or branched, usually hairy and leafy. The leaves are 1 to 6 inches in length, lance shaped and sharp pointed at the top, with wavy toothed margins narrowing toward the base. With the exception of some of the leaves near the base, most of them are stemless. The spikes of fragrant sulphur-yellow flowers are produced from about June to October and, as already stated and as indicated by the name "evening" primrose, they are open late in the evening and during the night. They are borne at the end of the stem and are interspersed with leafy bracts. Each flower has four spreading

petals and measures about 1 to 2 inches across. The seed capsules are oblong and hairy, about an inch in length, and narrowed at the top. (Fig. 6.) This plant belongs to the evening primrose family (Onagraceæ).

Collection, prices, and uses.—The entire plant is used. It is collected about flowering time, bringing about 5 cents a pound. The herb has a somewhat astringent and mucilaginous taste, but no odor. It has been used for coughs and asthmatic troubles, and an ointment made therefrom has been employed as an application in skin affections.

YERBA SANTA.

Eriodictyon californicum (H. and A.) Greene.

Pharmacopœial name.—*Eriodictyon*.

Synonym.—*Eriodictyon glutinosum* Benth.

Other common names.—Mountain balm, consumptive's weed,¹ bear's-weed, gum plant, tarweed.

Description.—This evergreen shrub, a member of the waterleaf family (Hydrophyllaceæ), reaches a height of from 3 to 4 feet, bearing glutinous leaves. The stem is smooth, but exudes a gummy substance. The dark-green leaves are from 3 to 4 inches in length, placed alternately on the stem, oblong or oval lance shaped, leathery, narrowing gradually into a short stalk, and with margins generally toothed, except perhaps at the base: the upper surface is smooth, with depressed veins, the prominent veins on the under surface forming a strong network and the spaces between the veins covered with short felty hairs, giving it a white appearance. The leaves are coated with a resinous substance, making them appear as if varnished. The rather showy whitish or pale-blue flowers are borne in clusters at the top of the plant, the tubular, funnel-shaped corolla measuring about half an inch in length and having five spreading lobes. (Fig. 7.) The seed capsule is oval, grayish brown, and contains small, reddish-brown, shriveled seeds.



FIG. 7.—Yerba santa (*Eriodictyon californicum*), leaves and flowers.

Collection, prices, and uses.—The leaves are the parts collected for medicinal use and are official in the United States Pharmacopœia. The price paid for them is about 5 cents a pound. Yerba santa has expectorant properties and is employed for throat and bronchial affections. It is also used as a bitter tonic. The odor is aromatic and the taste balsamic and sweetish.

¹ A popular but misleading name.

PIPSISSEWA.

Chimaphila umbellata (L.) Nutt.*Pharmacopœial name*.—*Chimaphila*.*Synonyms*.—*Pyrola umbellata* L.; *Chimaphila corymbosa* Pursh.*Other common names*.—Prince's pine, pyrola, rheumatism weed, bitter wintergreen, ground holly, king's cure, love-in-winter, noble pine, pine tulip.*Habitat and range*.—Pipsissewa is a native of this country, growing in dry, shady woods, especially in pine forests, and its range extends from Nova Scotia to British Columbia, south to Georgia, Mexico, and California. It also occurs in Europe and Asia.*Description*.—This small perennial herb, a foot or less in height, has a long, running, partly underground stem. It belongs to the heath family (Ericacæ) and has shining evergreen leaves of a somewhat leathery texture placed in a circle around the stem, usually near the top or scattered along it. They are dark green, broader at the top, with a sharp or blunt apex, narrowing toward the base and with margins sharply toothed; they are from about 1 to 2 inches long and about three-eighths to a little more than half an inch wide at the broadest part. From about June to August the pipsissewa may be found in flower, its pretty waxy-white or pinkish fra-

FIG. 8.—Pipsissewa (B) and spotted wintergreen (A) (*Chimaphila umbellata* and *C. maculata*), flowering and fruiting plants.

grant flowers, consisting of five rounded, concave petals, each one with a dark-pink spot at the base, nodding in clusters from the top of the erect stem. The brown capsules contain numerous very small seeds. (Fig. 8.)

Collection, prices, and uses.—Although the United States Pharmacopœia directs that the leaves be used, the entire plant is frequently employed, as all parts of it are active. Pipsissewa leaves have no odor, but a bitter, astringent taste. They bring about 4 cents a pound. Pipsissewa has slightly tonic, astringent, and diuretic properties and is sometimes employed in rheumatic and kidney affections. Externally it has been applied to ulcers.

Another species.—The leaves of the spotted wintergreen (*Chimaphila maculata* Pursh) were official in the Pharmacopœia of the United States from 1830 to 1840. These may be distinguished from the leaves of *C. umbellata* (pipsissewa) by their olive-green color marked with white along the midrib and veins. They are lance shaped in outline and are broadest at the base instead of at the top as in *C. umbellata*.

MOUNTAIN LAUREL.

Kalmia latifolia L.

Other common names.—Broad-leaved laurel, broad-leaved kalmia, American laurel, sheep laurel, rose laurel, spurge laurel, small laurel, wood laurel, kalmia, calico bush, spoonwood, spoon-hunt, ivy bush, big-leaved ivy, wicky, calmoun.

Habitat and range.—The mountain laurel is found in sandy or rocky soil in woods from New Brunswick south to Ohio, Florida, and Louisiana.

Description.—This is an evergreen shrub from about 4 to 20 feet in height, with leathery leaves, and when in flower it is one of the most beautiful and showy of our native plants. It has very stiff branches and leathery oval or elliptical leaves borne on stems, mostly alternate, pointed at both ends, with margins entire, smooth and bright green on both sides, and having terminal, clammy-hairy clusters of flowers, which appear from about May to June. The buds are rather oddly shaped and fluted, at first of a deep rose color, expanding



FIG. 9.—Mountain laurel (*Kalmia latifolia*). leaves and flowers.

into saucer-shaped, more delicately tinted, whitish-pink flowers. Each saucer-shaped flower is provided with 10 pockets holding the anthers of the stamens, but from which these free themselves elastically when the flower is fully expanded. (Fig. 9.) The seed capsule is somewhat globular, the calyx and threadlike style remaining attached until the capsules open. Mountain laurel, which belongs to the heath family (*Ericacæ*), is poisonous to sheep and calves.

Collection, prices, and uses.—The leaves, which bring about 3 to 4 cents a pound, are collected in the fall. They are used for their astringent properties.

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GRAVEL PLANT.

Epigaea repens L.

Other common names.—Trailing arbutus, Mayflower, shad-flower, ground laurel, mountain pink, winter pink.

Habitat and range.—This shrubby little plant spreads out on the ground in sandy soil, being found especially under evergreen trees from Florida to Michigan and northward.



FIG. 10.—Gravel plant (*Epigaea repens*), leaves and flowers.

Description.—The gravel plant is one of our early spring flowers, and under its more popular name "trailing arbutus" it is greatly prized on account of its delicate shell-pink, waxy blossoms with their faint yet spicy fragrance. Gravel plant is the name that is generally applied to it in the drug trade. It spreads on the ground with stems 6 inches or more in length and has rust-colored hairy twigs bearing evergreen leaves. The leaves are green above and below, thick and leathery, oval or roundish, sometimes with the top pointed, blunt, or having a short stiff point and a rounded or heart-shaped base. The margins are unbroken and the

upper surface is smooth, while the lower surface is somewhat hairy. The leaves measure from 1 to 3 inches in length and are about half as wide, the hairy stalks supporting them ranging from one-fourth of an inch to 2 inches in length. Early in the year, from about March to May, the flower clusters appear. These are borne in the axils of the leaves and at the ends of the branches and consist of several waxy, pinkish-white, fragrant flowers with saucer-shaped, 5-lobed corolla, the throat of the corolla tube being very densely hairy within. (Fig. 10.) The seed capsule is somewhat roundish, flattened, five celled, and contains numerous seeds. The gravel plant belongs to the heath family (Ericaceæ) and is a perennial.

Collection, prices, and uses.—The leaves are collected at flowering time and are worth about 3 or 4 cents a pound. They have a bitter, astringent taste and are said to possess astringent and diuretic properties.

WINTERGREEN.

Gaultheria procumbens L.

Other common names.—*Gaultheria*, spring wintergreen, creeping wintergreen, aromatic wintergreen, spicy wintergreen, checkerberry, teaberry, partridge berry, grouseberry, spiceberry, chickenberry, deerberry, groundberry, hillberry, ivyberry, boxberry, redberry tea, Canadian tea, mountain tea, ivory plum, chinks, drunkards, red pollom, rapper dandies, wax cluster.

Habitat and range.—This small native perennial frequents sandy soils in cool damp woods, occurring especially under evergreen trees in Canada and the northeastern United States.

Description.—Wintergreen is an aromatic, evergreen plant with an underground or creeping stem producing erect branches not more than 6 inches in height, the lower part of which is smooth and naked, while near the ends are borne the crowded clusters of evergreen leaves. These are alternate, shining dark green above, lighter colored underneath, spicy, thick and leathery, oval and narrowing toward the base, 1 to 1½ inches in length, and of varying width. From about June to September the solitary, somewhat urn-shaped and five-toothed white and waxy flowers appear, borne on recurved stems in the axils of the leaves. (Fig. 11.) These are followed by globular, somewhat flattened berries, which ripen in autumn and remain on the plant, sometimes until spring. They are bright red, five celled, mealy, and spicy. All parts of the plant, which belongs to the heath family (*Ericaceæ*), are aromatic.

Collection, prices, and uses.—The leaves of wintergreen, or *Gaultheria*, were at one time official in the United States Pharmacopœia, but now only the oil of wintergreen, distilled from the leaves, is so regarded. The leaves should be collected in autumn. Sometimes the entire plant is pulled up and, after drying, the leaves readily shake off. The price paid to collectors ranges from about 3 to 4 cents a pound.

Wintergreen has stimulant, antiseptic, and diuretic properties. Its chief use, however, seems to be as a flavoring agent.

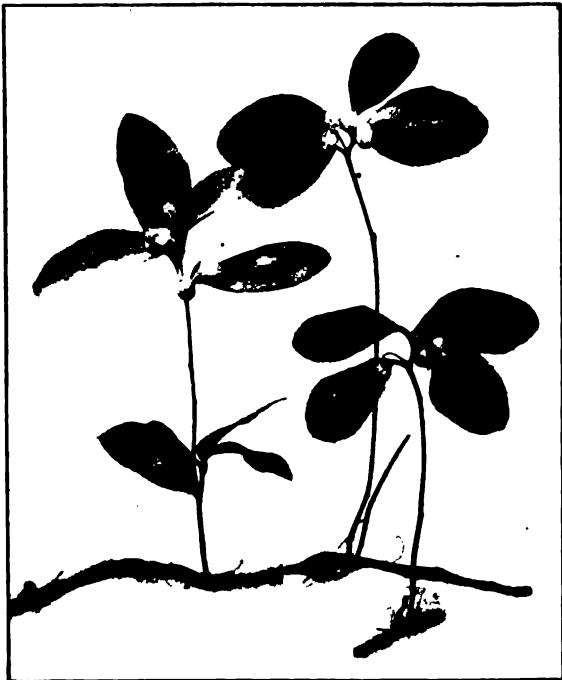


FIG. 11.—Wintergreen (*Gaultheria procumbens*), flowering and fruiting plants.

BEARBERRY.

Arctostaphylos uva-ursi (L.) Spreng.*Pharmacopœial name.*—*Uva ursi*.

Other common names.—Red bearberry, bear's-grape, bear's bilberry, bear's whortleberry, foxberry, upland cranberry, mountain cranberry, crowberry, mealberry, rockberry, mountain box, kinnikinnic, killikinic, universe vine, brawlins, burren myrtle,

creashak, sagachomi, rapper dandies (fruit).

Habitat and range.—

Bearberry is a native of this country, growing in dry sandy or rocky soil from the Middle Atlantic States north to Labrador and westward to California and Alaska.

Description.—The bearberry is a low, much-branched shrub trailing over the ground and having leathery, evergreen leaves. It is a member of the heath family (*Ericaceæ*) and produces its pretty waxy flowers about May.

The numerous crowded leaves are thick and leathery, evergreen, about one-half to 1 inch in length, blunt and widest at the top and narrowing at the base, with a network of fine veins, smooth, and with margins entire. The flowers are few, borne in short drooping clusters at the ends of the branches, and are ovoid



FIG. 12.—Bearberry (*Arctostaphylos uva-ursi*), leaves and fruits.

or somewhat bell shaped in form, four or five lobed, white with a pinkish tinge. They are followed by smooth, red, globular fruits, with an insipid, rather dry pulp, containing five nutlets. (Fig. 12.)

Collection, prices, and uses.—Bearberry or uva ursi leaves, official in the United States Pharmacopœia, are collected in autumn. Collectors receive from about 2 to 4 cents a pound for them. Bearberry leaves have a bitter, astringent taste and a faint odor. They act on the kidneys and bladder and have astringent and tonic properties.

Another species.—The leaves of manzanita (*Arctostaphylos glauca* Lindl.), a shrub-like tree, 9 to 25 feet high, have properties similar to uva ursi and are also used in medicine for similar purposes. They are of a leathery texture, pale green, ovate oblong in shape, with unbroken margins, and about 2 inches in length. Manzanita grows in California, in dry rocky districts on the western slopes of the Sierras.

BUCK BEAN.

Menyanthes trifoliata L.

Other common names.—Bog bean, bog myrtle, bog hop, bog nut, brook bean, bean trefoil, marsh trefoil, water trefoil, bitter trefoil, water shamrock, marsh clover, moonflower, bitterworm.

Habitat and range.—The buck bean is a marsh herb occurring in North America as far south as Pennsylvania, Minnesota, and California. It is also native in Europe.

Description.—This perennial herb arises from a long, black, creeping, scaly rootstock, the leaves being produced from the end of the same on erect sheathing stems measuring about 2 to 10 inches in height. The leaves consist of three oblong-oval or broadly oval leaflets $1\frac{1}{2}$ to 3 inches long, somewhat fleshy and smooth, blunt at the top, with margins entire and narrowed toward the base; the upper surface is pale green and the lower surface somewhat glossy, with the thick midrib light in color. The flower cluster is produced from May to July on a long, thick, naked stalk arising from the rootstock. It bears from 10 to 20 flowers, each with a funnel-shaped tube terminating in five segments which are pinkish purple or whitish on the outside and whitish and thickly bearded with white hairs within. (Fig.



FIG. 13.—Buck bean (*Menyanthes trifoliata*), flowering plant.

13.) The capsules which follow are ovate, blunt at the top, smooth and light brown, and contain numerous smooth and shining seeds. Buck bean is a perennial belonging to the buck-bean family (Menyanthaceæ).

Collection, prices, and uses.—The leaves are generally collected in spring. They lose more than three-fourths of their weight in drying. The price paid per pound is about 6 to 8 cents.

Buck-bean leaves have a very bitter taste, but no odor. Large doses are said to have cathartic and sometimes emetic action, but the principal use of buck-bean leaves is as a bitter tonic. They have been employed in dyspepsia, fevers, rheumatic and skin affections, and also as a remedy against worms.

The rootstock is also sometimes employed medicinally and was recognized in the United States Pharmacopœia from 1830 to 1840.

SKULLCAP.

Scutellaria lateriflora L.*Pharmacopœial name.*—*Scutellaria*.*Other common names.*—American skullcap, blue skullcap, mad-dog skullcap, side-flowering skullcap, madweed, hoodwort, blue pimpernel, hooded willow-herb.*Habitat and range.*—This species is native in damp places along banks of streams from Canada southward to Florida, New Mexico, and Washington.

FIG. 14.—Skullcap (*Scutellaria lateriflora*), flowering branch, showing also seed capsules.

Description.—The lip-shaped flowers and square stems of the skullcap indicate that it is a member of the mint family (Menthaceæ). It is a perennial of slender, erect habit, its square, leafy, branching stem ranging from 8 inches to 2 feet in height, smooth, or sometimes hairy at the top. The leaves are placed opposite to each other on the stem on slender stalks and are about 1 to 3 inches in length and about one-third as wide, thin in texture, oblong or lance-shaped, with margins coarsely toothed. They gradually become smaller toward the top, and sometimes those at the very top have the margins unbroken. The flowers are borne in narrow, spikelike, one-sided clusters, generally in the axils of the leaves, but frequently also at the top, and are

interspersed with leafy bracts. They appear from about July to September and are blue, shading off to whitish. The tubular, 2-lipped flowers are about a quarter of an inch in length, and the calyx, or outer green covering of the flower, is also two lipped, the upper lip shaped like a helmet and closing in fruit. (Fig. 14.)

Collection, prices, and uses.—The dried plant is at present official in the United States Pharmacopœia. The entire plant is collected when in flower and should be carefully dried in the shade. The price ranges from about 3 to 4 cents a pound.

Very frequently collectors will gather some other species in place of the official plant, most of those thus wrongly finding their way into the market being generally of stouter growth, with broader leaves and much larger flowers.

This plant was once considered valuable for the prevention of hydrophobia, whence the names "mad-dog skullcap" and "madweed," but it is now known to be useless for that purpose. It is used principally as a tonic and to a limited extent for allaying nervous irritation of various kinds.

HOREHOUND.

Marrubium vulgare L.*Pharmacopæial name.*—Marrubium.*Other common names.*—Houndsbene, marvel, marrube.

Habitat and range.—Horehound grows in dry sandy or stony soil in waste places, along roadsides and near dwellings, in fields, and pastures. It is found from Maine to South Carolina, Texas, and westward to California and Oregon. It is very abundant in pastures in Oregon and California, and especially in southern California, where it is a very troublesome weed, covering vast areas and in such dense masses as to crowd out all other vegetation. It has been naturalized from Europe.

Description.—The entire plant is thickly covered with hairs, which give it a whitish, woolly appearance. It is a bushy, branching herb, having a pleasant aromatic odor, and is about 1 to 3 feet high, with many woolly stems rounded below and four angled above, with opposite, oval or roundish, wrinkled, strongly veined, and very hoary leaves. The leaves are about 1 to 2 inches in length, placed opposite each other on the stem, oval or nearly round, somewhat blunt at the apex, and narrowed or somewhat heart shaped at the base, the margins round toothed; the upper surface is wrinkled and somewhat hairy, while the lower surface is very hoary and prominently veined. The lip-shaped flowers, which appear from June to September, show that it is a member of the mint family (Mentha-cæ). These are borne in dense woolly clusters in the axils of the leaves and are whitish, two lipped, the upper lip two lobed, the lower three lobed. The hooked calyx teeth of the mature flower heads cling to the wool of sheep, resulting in the scattering of the seeds. (Fig. 15.)

Collection, prices, and uses.—The leaves and tops are the parts used in medicine and are official in the United States Pharmacopœia. These are gathered just before the plant is in flower, the coarse stalks being rejected. They should be carefully dried in the shade. The odor is pleasant, rather aromatic, but diminishes in drying. The taste is bitter and persistent. Horehound at present brings about 1½ to 2 cents a pound.

It is well known as a domestic remedy for colds and is also used in dyspepsia and for expelling worms.



FIG. 15. —Horehound (*Marrubium vulgare*), leaves, flowers, and seed clusters.

CATNIP.

Nepeta cataria L.

Other common names.—Cataria, catmint, catwort, catrup, field mint.

Habitat and range.—Catnip, a common weed naturalized from Europe, occurs in rather dry soil in waste places and cultivated land from Canada to Minnesota and south to Virginia and Arkansas.

Description.—The fine white hairs on the stems of this plant give it a somewhat whitish appearance. Catnip reaches about 2 to 3 feet in height, with erect, square, and branched stems. It is a perennial belonging to the mint family (Menthacæ).

The opposite leaves are heart shaped or oblong, with a pointed apex, the upper surface green, the lower grayish green with fine white hairs, the margins finely scalloped and 1 to 2½ inches in length.

About June to September the many-flowered, rather thick spikes are produced at the ends of the stem and branches. The whitish flowers, dotted with purple, are two lipped, the upper lip notched or two cleft, the lower one with three lobes, the middle lobe broadest and sometimes two cleft. (Fig. 16).

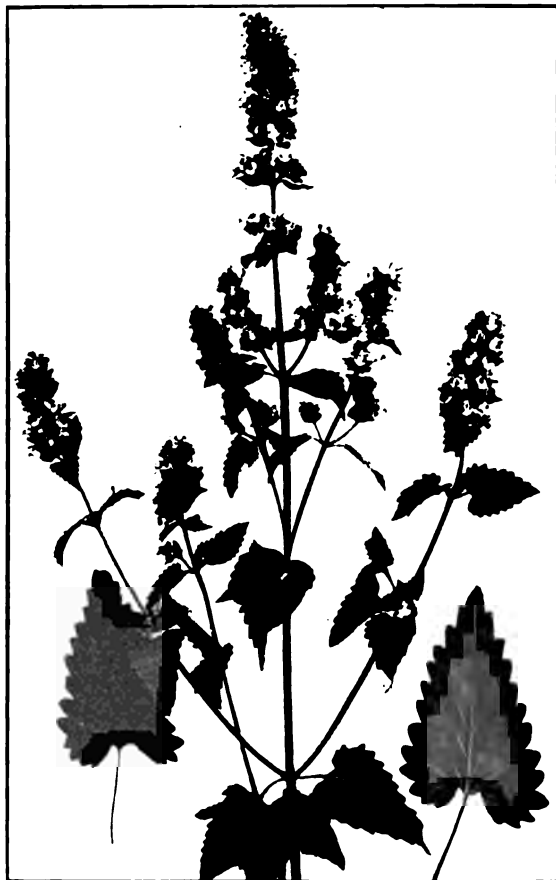


FIG 16.—Catnip (*Nepeta cataria*), leaves and flowers.

Collection, prices, and uses.—The leaves and flowering tops, which have a strong odor and a bitter taste, are collected when the plant is in flower and are carefully dried. The coarser stems and branches should be rejected. Catnip was official in the United States Pharmacopœia from 1840 to 1880. The price ranges from 3 to 5 cents a pound.

Catnip is used as a mild stimulant and tonic and as an emmenagogue. It also has a quieting effect on the nervous system.

MOTHERWORT.

Leonurus cardiaca L.*Synonym.*—*Cardiaca vulgaris* Moench.*Other common names.*—Throwwort, cowthwort, lion's-tail, lion's-ear.

Habitat and range.—Motherwort, naturalized from Europe and a native also of Asia, is found about dwellings and in waste places, its range in this country extending from Nova Scotia to North Carolina, Minnesota, and Nebraska.

Description.—The rather stout, erect, 4-angled stem of this perennial herb attains a height of from 2 to 5 feet, is sparingly hairy, and has upright branches. The rough, dark-green leaves are borne on long stems, the lower ones rounded, about 2 to 4 inches wide and three to five lobed, the lobes pointed, toothed, or variously cut, the upper narrower ones three cleft with lance-shaped lobes. Motherwort flowers in summer, the pale-purple or pinkish lip-shaped blossoms produced in the axils of the leaves being arranged in dense circles around the stem; the upper lip is densely covered with white, woolly hairs on the outside and the lower lip is three lobed and mottled. (Fig. 17.) Motherwort belongs to the mint family (Menthacæ).

Collection, prices, and uses.—The leaves and flowering tops are collected during the flowering season. They have an aromatic odor and a very bitter taste. At present they bring about 3 to 5 cents a pound.

Motherwort has stimulant, slightly tonic properties and is used also to promote perspiration.

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FIG. 17.—Motherwort (*Leonurus cardiaca*), leaves, flowers, and seed clusters.

PENNYROYAL.

Hedeoma pulegioides (L.) Pers.*Pharmacopœial name*.—Hedeoma.*Other common names*.—American pennyroyal, mock pennyroyal, squaw mint, tickweed, stinking balm, mosquito plant.FIG. 18.—Pennyroyal (*Hedeoma pulegioides*), leaves and flowers.*Habitat and range*.—Pennyroyal is found in dry soil from Nova Scotia and Quebec to Dakota and southward.*Description*.—This very strongly aromatic annual of the mint family (Menthacæ) is of rather insignificant appearance, being a low-growing plant, about 6 inches to a foot or so in height, with a slender, erect, much-branched and somewhat hairy stem.

The opposite leaves are small, scarcely exceeding three-fourths of an inch in length and becoming smaller toward the top of the plant. They are borne on short stems and are oblong ovate in shape, thin, blunt at the apex, narrowed at the base, and with margins sparingly toothed. The branchlets are four-angled and somewhat hairy, and the loose flower clusters, appearing from July to September in the axils of the leaves, consist of a few pale-bluish flowers with 2-

lipped corolla, the erect upper one entire or slightly notched or two lobed, while the lower spreading lip is three cleft. (Fig. 18.)

Collection, prices, and uses.—The leaves and flowering tops are official in the United States Pharmacopœia, as is also the oil of pennyroyal distilled from them. They should be collected while in flower. The price paid to collectors ranges from about 1½ to 2½ cents a pound.

Pennyroyal has a strong mintlike odor and pungent taste and is used as an aromatic stimulant, carminative, and emmenagogue. The odor is very repulsive to insects, and pennyroyal is therefore much used for keeping away mosquitoes and other troublesome insects.

BUGLEWEED.

Lycopus virginicus L.

Other common names.—Buglewort, sweet bugleweed, American water horchound, carpenter's herb, green archangel, gypsyweed, Paul's betony, wood betony, wolf foot, purple archangel, water bugle, gypsywort, gypsy herb, Virginia horehound.

Habitat and range.—Bugleweed is a native herb frequenting wet, shady places from Canada to Florida, Missouri, and Nebraska.

Description.—This perennial herb of the mint family (Menthacæ) has long, threadlike runners and a bluntly 4-angled, smooth, slender, erect or ascending stem from 6 inches to 2 feet in height. The leaves are dark green or of a purplish tinge, about 2 inches in length, long pointed at the apex and narrowed toward the base, the upper portion of the margin being toothed. The small, tubular, bell-shaped, 4-lobed flowers are purplish and are produced from about July to September. They are borne in dense clusters in the axils of the leaves and are followed by 3-sided nutlets. (Fig. 19.)



FIG. 19.—Bugleweed (*Lycopus virginicus*), leaves and flowers.

Collection, prices, and uses.—The entire herb, which was official from 1830 to 1880, should be gathered during the flowering period. It brings about 3 to 4 cents a pound. The plant has a rather pleasant, mintlike odor, but the taste is bitter and disagreeable. It has sedative, tonic, and astringent properties.

PEPPERMINT.

Mentha piperita L.*Pharmacopæial name*.—*Mentha piperita*.*Other common names*.—American mint, brandy mint, lamb mint, lammint, State mint (in New York).*Habitat and range*.—Peppermint is naturalized from Europe and is found in damp places from Nova Scotia to Minnesota and south to Florida and Tennessee. It is

largely cultivated, principally in Michigan and New York, where the distillation of the plants for the oil is carried on a very extensive scale, and also in parts of Indiana, Iowa, and Wisconsin.

Description.—Peppermint propagates by means of its long, running roots, from which are produced smooth, square stems, from 1 to 3 feet in height, erect and branching. The dark-green leaves are borne on stalks and are lance shaped, 1 to 2 inches in length and about half as wide, pointed at the apex and rounded or narrowed at the base, with margins sharply toothed; they are smooth on both sides, or sometimes the veins on the lower surface are hairy.

This aromatic perennial of the mint family (Menthacæ) is in flower from July to September, the small purplish blossoms having a tubular, 5-toothed

FIG. 20.—Peppermint (*Mentha piperita*), leaves and flowers.

calyx and a 4-lobed corolla. They are placed in circles around the stem, forming thick, blunt, terminal spikes. (Fig. 20.)

Collection, prices, and uses.—The dried leaves and flowering tops are the parts directed to be used by the United States Pharmacopœia. These must be collected as soon as the flowers begin to open and should be carefully dried in the shade. Dried peppermint leaves and tops bring about $3\frac{1}{2}$ to $4\frac{1}{2}$ cents a pound.

The pungent odor of peppermint is familiar, as is likewise the agreeable taste, burning at first and followed by a feeling of coolness in the mouth. It is a well-known remedy for stomach and intestinal troubles.

The oil, which is obtained by distillation with water from the fresh or partially dried leaves and flowering tops, is also official in the United States Pharmacopœia. While a less acreage was devoted to peppermint during 1910, conditions were favorable to its growth, and the crop is estimated to have amounted to about 200,000 pounds. The wholesale quotations for peppermint oil in the spring of 1911 ranged from \$2.85 to \$2.95 a pound.

SPEARMINT.

Mentha spicata L.

Pharmacopœial name.—*Mentha viridis*.

Synonym.—*Mentha viridis* L.

Other common names.—Mint, brown mint, garden mint, lamb mint, mackerel mint, Our Lady's mint, sage of Bethlehem.

Habitat and range.—Like peppermint, the spearmint has also been naturalized from Europe and may be found in moist fields and waste places from Nova Scotia to Utah and south to Florida. It is also cultivated to some extent for the distillation of the oil and is a familiar plant in gardens for domestic use.

Description.—Spearmint very much resembles peppermint. It does not grow perhaps quite so tall, the lance-shaped leaves are generally stemless or at least with very short stems, and the flowering spikes are narrow and pointed instead of thick and blunt. (Fig. 21.) The flowering period is the same as for peppermint—from July to September.

Collection, prices, and uses.—The dried leaves and flowering tops are official in the United States Pharmacopœia and should be collected before the flowers are fully developed. The price at present is about 3½ cents a pound.

Spearmint is used for similar purposes as peppermint, although its action is milder. The odor and taste closely resemble those of peppermint, but a difference may be detected, the flavor of spearmint being by some regarded as more agreeable. Oil of spearmint is also official in the United States Pharmacopœia. It is obtained from the fresh or partially dried leaves and flowering tops.



FIG. 21.—Spearmint (*Mentha spicata*), leaves, flowers, and running rootstock.

JIMSON WEED.

Datura stramonium L.*Pharmacopœial name.*—Stramonium.

Other common names.—Jamestown weed (from which the name "jimson weed" is derived), Jamestown lily, thorn apple, devil's apple, mad-apple, apple of Peru, stinkweed, stinkwort, devil's trumpet, fireweed, dewtry.

Habitat and range.—This is a very common weed in fields and waste places almost everywhere in the United States except in the North and West. It is widely scattered in nearly all warm countries.

Description.—Jimson weed is an ill-scented, poisonous annual belonging to the nightshade family (Solanaceæ). Its stout, yellowish-green stems are about 2 to 5 feet high, much forked, and leafy with large, thin, wavy-toothed leaves. The leaves are from 3 to 8 inches long, thin, smooth, pointed at the top and usually narrowed at the base, somewhat lobed or irregularly toothed and waved, veiny, the upper surface dark green, while the lower surface is a lighter green. The flowers are large (about 3 inches in length), white, funnel



FIG. 22.—Jimson weed (*Datura stramonium*), leaves, flowers, and capsules.

shaped, rather showy, and with a pronounced odor. Jimson weed is in flower from about May to September, and the seed pods which follow are dry, oval, prickly capsules, about as large as a horse-chestnut, which upon ripening burst open into four valves containing numerous black, wrinkled, kidney-shaped seeds, which are poisonous. (Fig. 22.)

Collection, prices, and uses.—The leaves of the jimson weed, yielding, when assayed by the United States Pharmacopœia process, not less than 0.35 per cent of its alkaloids, are official under the name "Stramonium." They are collected at the time jimson weed is in flower, the entire plant being cut or pulled up and the leaves stripped and carefully dried in the shade. They have an unpleasant, narcotic odor and a bitter, nauseous taste. Drying diminishes the disagreeable odor. The collector may receive from 2 to 5 cents a pound for the leaves.

The leaves, which are poisonous, cause dilation of the pupil of the eye and also have narcotic, antispasmodic, anodyne, and diuretic properties. In asthma they are frequently employed in the form of cigarettes, which are smoked, or the fumes are inhaled.

The seeds are also used in medicine.

BALMONY.

Chelone glabra L.

Other common names.—Turtlehead, turtle bloom, fishmouth, codhead, salt-rheum weed, snake-head, bitter herb, shell flower.

Habitat and range.—This native perennial grows in swamps and along streams from Newfoundland to Manitoba and south to Florida and Kansas.

Description.—Balmony is a slender, erect herb, with a 4-angled stem 1 to 3 feet in height, occasionally branched. The short-stemmed leaves, which are from 3 to 6 inches in length, are narrowly lance shaped to broadly lance shaped, the lower ones sometimes broadly oval, narrowing toward the base and with margins furnished with sharp, close-lying teeth. In late summer or early fall the showy clusters of whitish or pinkish flowers are produced. Each flower is about an inch in length, with a tubular, inflated corolla, with the mouth slightly open and resembling the head of a turtle or snake; its broad arched upper lip is keeled in the center and notched at the apex, while the lower lip is three lobed, the smallest lobe



FIG. 23.—Balmony (*Chelone glabra*). leaves and flowers.

in the center, and the throat bearded with woolly hairs. (Fig. 23.) The seed capsule is oval, about half an inch in length, and contains numerous small seeds.

Collection, prices, and uses.—The herb (especially the leaves), which brings from 3 to 4 cents a pound, should be collected during the flowering period.

Balmony has a very bitter taste, but no odor, and is used as a tonic, for its cathartic properties, and for expelling worms.

COMMON SPEEDWELL.

Veronica officinalis L.

Other common names.—Paul's betony, ground-hele, fluellin, upland speedwell.

Habitat and range.—This little herb frequents dry fields and woods from Nova Scotia to Michigan and south to North Carolina and Tennessee. It also occurs in Europe and Asia.

Description.—The common speedwell creeps over the ground by means of rather

woody stems rooting at the joints and sends up branches from 3 to 10 inches in height. It is hairy all over. The leaves are opposite to each other on the stem, on short stalks, grayish green and soft hairy, oblong or oval in shape, and about one-half to an inch in length; they are blunt at the apex, with margins saw toothed and narrowing into the stalks. From about May to July the elongated, narrow, spikelike flower clusters are produced from the leaf axils, crowded with small, pale-blue flowers. (Fig. 24.) The capsule is obovate, triangular, and compressed, and contains numerous flat seeds. The speedwell is a perennial belonging to the figwort family (Scrophulariaceæ).

Collection, prices, and uses.—The leaves and flowering tops, which bring about 3 to 5 cents a pound, should be collected about



FIG. 24.—Common speedwell (*Veronica officinalis*), leaves and flowers.

May or June. When fresh they have a faint, agreeable odor, which is lacking when dry. The taste is bitter and aromatic and somewhat astringent.

Speedwell has been used for asthmatic troubles and coughs and also for its alterative, tonic, and diuretic properties.

FOXGLOVE.

Digitalis purpurea L.

Pharmacopœial name.—*Digitalis*.

Other common names.—Purple foxglove, thimbles, fairy cap, fairy thimbles, fairy fingers, fairy bells, dog's-finger, finger flower, lady's-glove, lady's-finger, lady's-thimble, popdock, flap dock, flop dock, lion's-mouth, rabbit's-flower, cottagers, throatwort, Scotch mercury.

Habitat and range.—Originally introduced into this country from Europe as an ornamental garden plant, foxglove may now be found wild in a few localities in parts of Oregon, Washington, and West Virginia, having escaped from cultivation and assumed the character of a weed. It occurs along roads and fence rows, in small cleared places, and on the borders of timber land.

Description.—Foxglove, a biennial or perennial belonging to the figwort family (Scrophulariaceæ), during the first year of its growth produces only a dense rosette of leaves, but in the second season the downy and leafy flowering stalk, reaching a height of 3 to 4 feet, appears. The basal leaves are rather large, with long stalks, while the upper ones gradually become smaller and are borne on shorter leafstalks. The ovate or oval leaves, 4 to 12 inches long and about half as wide, the upper surface of which is dull green and wrinkled, are narrowed at the base into long winged stalks; the lower surface of the leaves shows a thick network of prominent veins and is grayish, with soft, short hairs. The apex is blunt or pointed and the margins are round toothed. When foxglove is in flower, about June, it is a most handsome plant, the long terminal clusters (about 14 inches in length) of numerous tubular, bell-shaped flowers making a very showy appearance. The individual flowers are about 2 inches long and vary in color from whitish through lavender and purple; the inside of the lower lobe is white, with crimson spots and furnished with long, soft, white hairs. (Fig. 25.) The capsule is ovoid, two celled, and many seeded.



FIG. 25.—Foxglove (*Digitalis purpurea*), leaves and flowers.

Collection, prices, and uses.—The leaves, which are official in the United States Pharmacopœia, are collected from plants of the second year's growth just about the time that they are coming into flower. They should be very carefully dried in the shade soon after collection and as rapidly as possible, preserving them in dark, airtight receptacles. The leaves soon lose their medicinal properties if not properly dried or if exposed to light and moisture. Foxglove brings about 6 to 8 cents a pound. At present most of the foxglove or digitalis used comes to this country from Europe, where the plant grows wild and is also cultivated.

Foxglove has a faint, rather peculiar odor and a very bitter, nauseous taste. Preparations made from it are of great value in affections of the heart, but they are poisonous and should be used only on the advice of a physician.

SQUAW VINE.

Mitchella repens L.

Other common names.—Checkerberry, partridgeberry, deerberry, hive vine, squawberry, twinberry, chickenberry, cowberry, boxberry, foxberry, partridge vine, winter clover, wild running box, oneberry, pigeonberry, snakeberry, two-eyed berry, squaw-plum.



FIG. 26.—Squaw vine (*Mitchella repens*), leaves and fruits.

Habitat and range.—The squaw vine is common in woods from Nova Scotia to Minnesota and south to Florida and Arkansas, where it is generally found creeping about the bases of trees.

Description.—This slender, creeping or trailing evergreen herb, a member of the madder family (Rubiaceæ), has stems 6 to 12 inches long, rooting at the joints, and roundish-oval, rather thick, shining, dark-green opposite leaves about half an inch in length, which are blunt at the apex and rounded or somewhat heart shaped at the base, with margins entire. Sometimes the leaves show whitish veins. The plant flowers from about April to June, producing fragrant whitish, sometimes pale-purplish, funnel-shaped and 4-lobed flowers, two borne to-

gether on a stalk and having the ovaries (seed-bearing portion) united, resulting in a double, berrylike fruit. These fruits are red and contain eight small, bony nutlets. (Fig. 26.) They remain on the vine through the winter and are edible, though practically tasteless.

Collection, prices, and uses.—The leaves and stems (herb) are collected at almost any time of the year and range in price from about 3½ to 4 cents a pound.

The leaves have no odor and are somewhat astringent and bitter. Squaw vine has tonic, astringent, and diuretic properties.

LOBELIA.

Lobelia inflata L.

Pharmacopœial name.—Lobelia.

Other common names.—Indian tobacco, wild tobacco, asthma weed, gagroot, vomitwort, puke weed, emetic herb, bladder pod, low belia, eyebright.

Habitat and range.—Lobelia may be found in sunny situations in open woodlands, old fields and pastures, and along roadsides nearly everywhere in the United States, but especially east of the Mississippi River.

Description.—This poisonous plant, an annual belonging to the bellflower family (Campanulacæ), contains an acrid, milky juice. Its simple stem has but few short branches and is smooth above, while the lower part is rough hairy.

The leaves are placed alternately along the stem, those on the upper portion small and stemless and the lower leaves larger and borne on stalks. They are pale green and thin in texture, from 1 to about 2 inches in length, oblong or oval, blunt at the apex, the margins irregularly saw toothed, and both upper and lower surfaces furnished with short hairs.

Lobelia may be found in flower from summer until frost, but its pale-blue flowers, while very numerous, are very small and inconspicuous. They are borne on very short stems in the axils of the upper leaves. The lower lip of each flower has three lobes and the upper one two segments, from the center of which the tube is cleft to the base. The inflated capsules are nearly round, marked with parallel grooves, and contain very numerous extremely minute dark-brown seeds. (Fig. 27.)

Collection, prices, and uses.—The Pharmacopœia directs that the leaves and tops be collected after some of the capsules have become inflated. Not too much of the stemmy portion should be included. The leaves and tops should be dried in the shade and when dry kept in covered receptacles. The price paid for the dried leaves and tops is about 3 cents a pound.

Lobelia has expectorant properties, acts upon the nervous system and bowels, causes vomiting, and is poisonous.

The seed of lobelia is also employed in medicine.



FIG. 27.—Lobelia (*Lobelia inflata*), leaves, flowers, and inflated capsules.

BONESET.

Eupatorium perfoliatum L.*Pharmacopœial name*.—*Eupatorium*.*Synonym*.—*Eupatorium connatum* Michx.

Other common names.—Thoroughwort, thorough-stem, thoroughwax, wood boneset, teasel, agueweed, feverwort, sweating plant, crosswort, vegetable antimony, Indian sage, wild sage, tearal, wild isaac.



FIG. 28.—Boneset (*Eupatorium perfoliatum*), leaves and flowers.

Habitat and range.—Boneset is a common weed in low, wet ground, along streams, and on the edges of swamps and in thickets from Canada to Florida and west to Texas and Nebraska.

Description.—This plant is easily recognized by the peculiar arrangement of the leaves, which are opposite to each other, but joined together at the base, which makes it appear as though they were one, with the stem passing through the center. It is a perennial plant belonging to the aster family (Asteraceæ), and is erect, growing rather tall, from 1 to 5 feet in height. The stout stems are rough hairy, and the leaves, united at the base, are rough, very prominently veined, wrinkled, dark green above,

lighter green and downy beneath, lance shaped, tapering to a point, and with bluntly toothed margins. The crowded, flat-topped clusters of flowers are produced from about July to September and consist of numerous white tubular flowers united in dense heads. (Fig. 28.)

Collection, prices, and uses.—The leaves and flowering tops, official in the United States Pharmacopœia, are collected when the plants are in flower, stripped from the stalk, and carefully dried. They lose considerable of their weight in drying. The price per pound for boneset is about 2 cents.

Boneset leaves and tops have a bitter, astringent taste and a slightly aromatic odor. They form an old and popular remedy in the treatment of fever and ague, as implied by some of the common names given to the plant. Boneset is also employed in colds, dyspepsia, jaundice, and as a tonic. In large doses it acts as an emetic and cathartic.

GUM PLANT.

(1) *Grindelia robusta* Nutt.; (2) *Grindelia squarrosa* (Pursh) Dunal.

Pharmacopœial name.—Grindelia.

Other common names.—(2) Broad-leaved gum plant, scaly grindelia.

Habitat and range.—The gum plant (*Grindelia robusta*) occurs in the States west of the Rocky Mountains, while the broad-leaved gum plant (*G. squarrosa*) is more widely distributed, being of common occurrence on the plains and prairies from the Saskatchewan to Minnesota, south to Texas and Mexico, and westward to California.

Description.—The name "gum plant" is applied especially to *Grindelia robusta* on account of the fact that the entire plant is covered with a resinous substance, giving it a gummy, varnished appearance. It is an erect perennial herb belonging to the aster family (Asteraceæ) and has a round smooth stem, about 1½ feet in height. The leaves are pale green, leathery in texture and rather rigid, coated with resin and showing numerous translucent dots, and are about an inch in length. In outline they are oblong spatulate—that is, having a broad, rounded top gradually narrowing toward the base—clasping the stem and with margins somewhat saw toothed. The plant branches freely near the top, each branch somewhat reddish and terminating in a large yellow flower. The yellow flowers are about three-fourths of an inch in diameter, broader than long, and



FIG. 29.—Scaly grindelia (*Grindelia squarrosa*), leaves and flowers.

are borne singly at the ends of the branches. Immediately beneath the flower is a set of numerous, thick, overlapping scales (the involucre), the tips of which are rolled forward, the whole heavily coated with resin.

The broad-leaved gum plant (*Grindelia squarrosa*) is very similar to *G. robusta*, except that it is smaller and less gummy in appearance. It is more sparingly branched near the top and the branches seem more reddish. The leaves are also clasping, but they are longer, about 2 inches in length, and broader, thinner in texture and not rigid, and more prominently toothed. The smaller flower heads are generally longer than broad and have narrower involucre scales, the recurved tips of which are longer and more slender. (Fig. 29.)

Collection, prices, and uses.—The leaves and flowering tops of both species of *Grindelia* are official in the United States Pharmacopœia, and should be collected about

the time that the flowers have come into full bloom. The price ranges from about 5 to 10 cents a pound. While both species are official, the leaves and tops of *Grindelia squarrosa*, being more prevalent, are generally used.

The odor of *grindelia* is balsamic and the taste resinous, sharply aromatic, and slightly bitter. The drug is sometimes used in asthmatic and similar affections, as a stomachic, tonic, and externally in cases of poisoning by poison ivy.

CANADA FLEABANE.

Leptilon canadense (L.)
Britton.

Synonym.—*Erigeron canadensis* L.

Other common names.—*Erigeron*, horseweed, mare's-tail, Canada erigeron, butterweed, bitter-



FIG. 30.—Canada fleabane (*Leptilon canadense*), flowering tops.

weed, cow's-tail, colt's-tail, fireweed, bloodstanch, hogweed, prideweed, scabious.

Habitat and range.—Canada fleabane is common in fields and waste places and along roadsides almost throughout North America. It is also widely distributed as a weed in the Old World and in South America.

Description.—The size of this weed, which is an annual, depends upon the kind of soil in which it grows, the height varying from a few inches only to sometimes 10 feet in favorable soil. The erect stem is bristly hairy or sometimes smooth, and in the larger plants usually branched near the top. The leaves are usually somewhat hairy, the lower ones 1 to 4 inches long, broader at the top and narrowing toward the base, with margins toothed, lobed, or unbroken, while those scattered along the stem are rather narrow with margins generally entire. This weed, which belongs to the aster family (*Asteraceæ*), produces from June to November numerous heads of small, inconspicuous white flowers, followed by an abundance of seed. (Fig. 30.)

Collection, prices, and uses.—The entire herb is used; it should be collected during the flowering period and carefully dried. The price paid is about 5 to 6 cents a pound.

By distillation of the fresh flowering herb a volatile oil is obtained, known as oil of fleabane or oil of erigeron, which is sometimes employed in attempting to control hemorrhages and diarrheal affections. The leaves and tops were formerly official in the United States Pharmacopœia, from 1820 to 1880, but the oil alone is now recognized as official. The herb, which has a faint agreeable odor and an astringent and bitter taste, is also used for hemorrhages from various sources and the bleeding of wounds. It is also employed in diarrhea and dropsy.

YARROW.

Achillea millefolium L.

Other common names.—Millefolium, milfoil, thousand-leaf, thousand-leaf clover, gordolobo, green arrow, soldier's woundwort, nosebleed, dog daisy, bloodwort, sanguinary, carpenter's grass, old-man's-pepper, cammock.

Habitat and range.—Yarrow is very common along roadsides and in old fields, pastures, and meadows from the New England States to Missouri and in scattered localities in other parts of the country.

Description.—This weed, a perennial of the aster family (Asteraceæ), is about 10 to 20 inches in height and has many dark-green feathery leaves, narrowly oblong or lance shaped in outline and very finely divided into numerous crowded parts or segments. Some of the leaves, especially the basal ones, which are borne on stems, are as much as 10 inches in length and about half an inch or an inch in width. The leaves toward the top of the plant become smaller and stemless. From about June to September the flat-topped flowering heads are produced in abundance and consist of numerous small, white (sometimes rose-colored), densely crowded flowers. (Fig. 31.) Yarrow has a strong odor, and when it is eaten by cows the odor and bitter taste are transmitted to dairy products.



FIG. 31.—Yarrow (*Achillea millefolium*), leaves and flowers.

COLTSFOOT.

Tussilago farfara L.

Other common names.—Coughwort, assfoot, horsefoot, foalfoot, bull's-foot, horsehoof, colt-herb, clayweed, cleats, dove-dock, dummyweed, ginger, gingerroot, hoofs, sowfoot, British tobacco, gowan.

Habitat and range.—Coltsfoot has been naturalized in this country from Europe, and

is found along brooks and in wet places and moist clayey soil along roadsides from Nova Scotia and New Brunswick to Massachusetts, New York, and Minnesota.

Description.—In spring the white-woolly, scaly flowering stalks with their yellow blossoms are the first to appear, the leaves not being produced until the seed has formed or at least toward the latter part of the flowering stage. The flowering stalks are several, arising from the root, and are from 3 to 18 inches in height, each one bearing at the top a single, large yellow head, reminding one of a dandelion, having in the center what are called disk flowers, which are tubular, and surrounded by what are known as ray flowers, which are strap shaped.



FIG. 34.—Coltsfoot (*Tussilago farfara*), plant showing root, leaves, and flowers.

When the seed is ripe the head looks somewhat like a dandelion "blow." The flowering heads are erect, after flowering nodding, and again erect in fruit. The bright-yellow flowers only open in sunshiny weather. They have a honeylike odor.

The leaves, as already stated, appear when the flowers are almost through blossoming, or even afterwards. They are large, 3 to 7 inches wide, almost round or heart shaped in outline, or, according to some of the names applied to it, shaped like a horse's hoof; the margins are slightly lobed and sharply toothed. The upper surface is smooth and green, while the lower is white with densely matted woolly hairs. All the leaves arise from the root and are borne on long, erect stalks. (Fig. 34.)

Collection, prices, and uses.—All parts of coltsfoot are active, but the leaves are mostly employed; they should be collected in June or July, or about the time when they are nearly full size. When dry, they break very readily. Collectors are paid about 3½ cents a pound.

Coltsfoot leaves form a popular remedy in coughs and other affections of the chest and throat, having a soothing effect on irritated mucous membranes.

The flowers are also used; likewise the root.

FIREWEED.

Erechthites hieracifolia (L.) Raf.*Synonym*.—*Senecio hieracifolius* L.*Another common name*.—Pilewort.

Habitat and range.—Fireweed is found in woods, fields, and waste places from Canada to Florida, Louisiana, and Nebraska, springing up in especial abundance where land has been burned over, whence the name "fireweed."

Description.—This weed is a native of this country and is an ill-smelling annual belonging to the aster family (Asteraceæ). The stem is from 1 to 8 feet in height, grooved, branched, and juicy. The light-green leaves are rather large, from 2 to 8 inches long, thin in texture, lance shaped or oval lance shaped, the margins toothed or sometimes deeply cut. The upper ones usually have a clasping base or are at least stemless, while the margins of those lower down narrow into the stems.



FIG. 35.—Fireweed (*Erechthites hieracifolia*), leaves and flowering tops.

Fireweed is in flower from about July to September, the flat-topped clusters of greenish-white or whitish heads being produced from the ends of the stem and branches. The green outer covering of each flower head is cylindrical, with the base considerably swollen. (Fig. 35.) The seed is furnished with numerous soft white bristles.

Collection, prices, and uses.—The entire plant is used and is gathered in summer. The leaves turn black in drying. The price paid to collectors ranges from about 2 to 3 cents a pound.

An oil is obtained by distillation from the fresh plant. Fireweed has a disagreeable taste and odor. It has astringent, tonic, and alterative properties.

BLESSED THISTLE.

Cnicus benedictus L.

Synonyms.—*Centaurea benedicta* L.; *Carduus benedictus* Cam.; *Carbenia benedicta* Adans.

Other common names.—Holy thistle, St. Benedict's thistle, Our Lady's thistle, bitter thistle, spotted thistle, cursed thistle, blessed cardus, spotted cardus.



FIG. 36.—Blessed thistle (*Cnicus benedictus*), leaves and flowers.

The yellow flower heads, which appear from about May to August, are situated at the ends of the branches, almost hidden by the upper leaves, and are about an inch and a half in length. Immediately surrounding the yellow flower heads are scales of a leathery texture, tipped with long, hard, branching, yellowish-red spines. (Fig. 36.)

Collection, prices, and uses.—The leafy flowering tops and the other leaves are gathered preferably just before or during the blossoming period and then are thoroughly and quickly dried. In the fresh state the leaves and tops have a rather disagreeable odor, which they lose on drying. They are bright green when fresh and grayish green and woolly when dry. Collectors receive about 6 to 8 cents a pound.

The taste of the blessed thistle is very bitter and salty and somewhat acrid. It is used principally as a bitter tonic.

Habitat and range.—The blessed thistle is a weed which has been introduced into this country from southern Europe and is found in waste places and stony, uncultivated localities from Nova Scotia to Maryland and the Southern States; also on the Pacific coast. It is cultivated in many parts of Europe.

Description.—In height this annual plant of the aster family (Asteraceæ) scarcely exceeds 2 feet, with coarse erect stems, branched and rather woolly. The leaves are large, 3 to 6 inches long or more, oblong lance shaped, thin, more or less hairy, with margins wavy lobed and spiny. The lower leaves and those at the bottom are narrowed toward the base into winged stems, while those near the top are stemless and clasping.

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BUREAU OF PLANT INDUSTRY—BULLETIN NO. 220.

B. T. GALLOWAY, *Chief of Bureau.*

RELATION OF DROUGHT TO WEEVIL
RESISTANCE IN COTTON.

BY

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Bionomist in Charge of Crop Acclimatization and Adaptation Investigations.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., April 15, 1911.

SIR: I have the honor to transmit herewith a paper entitled "Relation of Drought to Weevil Resistance in Cotton," by Mr. O. F. Cook, of this Bureau, and to recommend its publication as Bulletin No. 220 of the Bureau series.

It has been ascertained that dry weather gives a distinct advantage in the production of cotton in the presence of the boll weevil. This relation is being taken into account in improving varieties and cultural methods in the direction of weevil resistance. The present report shows that several biological factors must be considered in the study of the practical problem of securing a rapid, uninterrupted development of the crop.

Respectfully,

WM. A. TAYLOR,
Acting Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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RELATION OF DROUGHT TO WEEVIL RESISTANCE IN COTTON.

INTRODUCTION.

An important relation between weevil resistance and drought resistance has been recognized for several years past. Special ability to resist drought is to be reckoned as one of the factors of weevil resistance, because more drought-resistant varieties can be grown in the drier regions of the Southwest, where the weevils are often unable to propagate and do relatively little damage. A rapid extension of cotton culture is taking place in this part of the United States.

The farming public in Texas is coming to look upon dry weather in the early part of the season as the most important factor in the production of a good crop of cotton. At first it was supposed that the fate of the weevils during the winter would determine the possibilities of production in the following season. Measures for reducing the number of weevils in the fall and spring received much attention, but it is now understood that dry weather makes it possible to secure a crop, even in a season when the weevils survive the winter in large numbers. In southern and western Texas the reduction of weevil injuries by drought is a very definite factor of weevil resistance, tending to place these regions more nearly on a basis of equality with other parts of the State for purposes of cotton production. In favorable seasons the same factor of dry weather becomes effective over much larger areas, as notably illustrated in the last two years, 1909 and 1910.

In order to take full advantage of other measures for combating the weevils, the relation of drought to the behavior of the growing plants must be considered, no less than the direct effect of the drought upon the weevils. Questions of the value of early and late varieties and of early and late planting require to be reconsidered and given further study now that the effects of dry weather are more fully appreciated. It is only by a careful study and full recognition of all the factors that the true possibilities of cotton culture in the presence of the weevils can be realized.

Without a supply of moisture in the soil the same drought that hinders the reproduction of the weevils will also stop the growth of the plants, thus reducing the advantage that might be gained from the dry weather. But if the land has been well prepared by deep plowing and thorough cultivation so that it absorbs and retains moisture, the plants continue to grow and set their crop through the dry weather. The weevils do not prosper during drought because the young larvæ are killed when the infested buds fall off and lie exposed on the hot, dry ground. The importance of thorough tillage is especially great in the very compact impervious soils of the "black-land prairies" that produce a large part of the Texas cotton crop. Unless such soils are stirred by cultivation very little water penetrates beyond the surface layers, and these are very soon dried out.

Under conditions of humidity other factors determine the success or failure of the crop. Wet and cloudy weather is likely to interfere with the growth of the plants without checking the propagation of the weevils. The more humid the climate the greater the necessity for a rapid, uninterrupted development of the plants if a crop is to be set before the weevils can prevent.

With conditions continuously favorable the weevils can seldom cause any complete loss of the crop, but if a period of unfavorable weather interrupts the growth of the cotton after the first crop of buds has been infested, enough weevils may be bred to infest all the subsequent buds, so that no crop can be set. The luxuriant growth of the plants may continue, each producing hundreds of flower buds, but all pruned off by the weevils. A whole field of the overluxuriant weevil-pruned cotton may not average more than two or three bolls to the plant.

The idea of avoiding weevil injuries by early planting needs to be supplemented by a recognition of the importance of securing an uninterrupted development of the plants. The chief object to be attained is the early setting of the crop in as short a period as possible after the plants have begun to produce flower buds in which the weevils can breed. This object should be taken into account in the breeding and adaptation of varieties and in devising improved methods of culture for weevil-infested regions.

COMPLETE CESSATION OF WEEVIL INJURIES DURING DROUGHT.

The condition of the cotton on the San Antonio Experiment Farm in the middle of July, 1909, afforded an unusually striking illustration of the importance of dry weather as a factor of cotton production in Texas. In spite of the fact that weevils appeared very numerous in the same fields early in the season and infested nearly

all of the first buds, no damage was being done in the middle of July, nor were there evidences of any recent injuries by weevils. A careful search over several different plats of cotton failed to find a single bud, or "square," with a normal weevil puncture. Weevil larvæ could still be found in very small numbers in old squares on the ground under the plants, but almost invariably dead or dying. Not a single adult weevil was found. The only weevils that appeared likely to survive were a few small larvæ in some of the earlier bolls, and these would not do further injury in that season, for the larvæ develop very slowly in the bolls and are not likely to emerge until the bolls open at maturity.

Careful examinations of the same plats had been made by Mr. S. H. Hastings, superintendent of the San Antonio farm, in May and June, when an unusually heavy infestation of weevils was found. Under date of June 14, Mr. Hastings reported that nearly all the buds had been destroyed by the weevils as fast as they were formed and that a total failure of the crop was threatened. Had the weather continued favorable for the weevils there was certainly no prospect that the later buds could have fared any better than their predecessors, but the advent of dry weather completely changed the situation and set a definite limit to the activities of the weevils. Similar cases had been observed in previous years when there seemed to be a lessening of weevil injuries as the season advanced instead of the increase that had been feared, but no such complete interruption of injuries by weevils during the growing season of the cotton had been observed.

The effects of heat and dryness upon the weevil larvæ were doubtless intensified indirectly by the influence of the drought upon the plants. Injured buds are dropped much more promptly in dry weather, and in severe drought even the uninjured buds may fall off, thus lessening still further the weevil's opportunities of propagation. The result of the earlier falling of the infested buds is to expose the larvæ to adverse conditions at earlier stages in their development and for longer periods of time.

The effect of the prolonged drought in completely preventing the continuation of the weevil injuries was not confined in the season of 1909 to the vicinity of San Antonio. The same condition of unusually heavy infestation appeared early in the season in the experiments conducted at Waco, Tex., by Dr. D. A. Saunders, and the same complete cessation of weevil injuries was observed with the advance of drought. Careful examination of several fields of cotton in the vicinity of Waco on August 18 and 19 by Dr. Saunders and the writer showed that no injury was being done by the weevils, though the insects remained active in more luxuriant fields on rich bottom lands of the same district.

Though the conditions of drought that gave the complete protection against the weevils were generally so severe as to interfere seriously with the growth of the plants and would undoubtedly have prevented the development of any considerable crop unless rain had come, the facts are of interest in their practical bearings upon the problem of weevil resistance. The complete cessation of weevil injuries, even after the weevils had survived the winter in unusual numbers and had begun to feed and breed in the buds of the young plants, makes it evident that the highest importance must be placed on the dry weather. The values of special weevil-resisting varieties and of special methods of culture must also be considered as means of gaining greater advantages from dry weather.

EARLY PLANTING IN DRY REGIONS.

The object that has been sought by early planting and by the use of early varieties is to give the cotton an opportunity to set as many bolls as possible early in the season, before the weevils have become numerous enough to infest all the buds and bolls and thus set a limit to the crop. A farmer who plants too late may have his cotton stocked with weevils from fields planted earlier by his neighbors and may suffer more seriously than they.

The best plan would be for a community to plant all of its cotton as nearly as possible at the same date. The date should be selected with a view to securing the most rapid development of the crop, and for this it is necessary that the plants make prompt and continuous growth. The amount of weevil injury is determined by the relation between the development of the cotton and the reproduction of the weevils. Any loss of time on the part of the cotton by delay or interruption of growth can only increase the relative proportion of weevil injury and diminish the crop. Anything that gives the cotton an advantage over the weevils should be taken into account in the problem of weevil resistance, whether the advantage is gained by methods of culture or by specialized characters of the plants themselves. The largest results are to be obtained by combining the cultural and the biological factors.

If each farmer attempts to plant earlier than his neighbors, the product of the community is likely to be reduced, for two reasons: Cotton that is planted too early may be injured so that maturity is retarded instead of being hastened and the weevils bred in early cotton may inflict increased injuries upon the later fields. Cotton that has been severely checked by cold or by extremes of wet or dry weather in the early stages of growth often suffers a permanent injury, either by being stunted in growth or by becoming abnormal in other respects. A smaller crop is obtained and that of inferior

quality. And even if no other change of characters takes place, experiments at San Antonio, Tex., in 1906 showed that the checking of the growth of an early planting may render it actually later in the development of its crop than a later planting of the same variety in the same place. Later planting not only secured more cotton, but a larger part of the crop was ripened before a given date, in spite of the fact that the plantings were made side by side, so that the later rows were readily accessible to the boll weevils bred in the early rows.¹

That the same result would be obtained in all cases is not to be expected, for these experiments were made under dry-weather conditions. But in the season of 1906 the summer drought was not severe enough to stop the reproduction of the weevils, all the plantings being quite seriously infested. The later plantings might have shown still greater superiority if they had been isolated from the early plantings, but in that case there could have been no assurance that other conditions of soil and moisture were the same.

If very early planting could insure a correspondingly early harvest, it might be argued that cotton should always be planted at the earliest possible date, without reference to scarcity or abundance of weevils. But in view of the experiments mentioned above, showing that later plantings may overtake very early plantings and ripen an earlier crop, it is plain that early planting, like any other cultural expedient, must be used with discretion and not carried to an unpractical extreme.

Of course, it is only in regions subject to drought that the weevils can be expected to become less destructive as the season advances, but in the dry regions of southern and western Texas this consideration seems to be of practical importance. Fields planted in May sometimes mature a full crop before being invaded at all by the weevils, even in localities where fields planted in March have suffered quite severely. Though such complete immunity of late plantings from weevil injuries may be of rare occurrence, the fact that good crops are sometimes secured in this way often leads the farmer to take the chance of a late sowing of cotton after a winter crop has been harvested or after some other spring crop has failed. The possibilities of late planting are obviously of much more importance in regions where winter crops can be grown than in more northern localities where the growing season is only long enough for the cotton and winter crops are not used, at least on land that is to be planted to cotton.

A heavy infestation of boll weevils in the early part of the season interferes with the growth of the plants long before the fruiting

¹ See "Local Adjustment of Cotton Varieties," Bulletin 159, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1909, p. 49.

stage is reached. The weevils begin by gnawing the terminal vegetative buds in the spring, before there are any flower buds to feed upon. This hinders growth of the young plants and forces the growth of vegetative branches at the base of the plants instead of allowing fruiting branches to be produced early in the season. Weevil-infested fields of cotton can often be recognized, even at a distance, by changes in habits of growth, before the differences in yield become apparent. Such expedients as the picking of the adult weevils by hand and the poisoning of the leaf buds of the young plants are much more advantageous early in the season, not only in reducing the number of weevils, but in allowing the cotton to make more rapid and normal growth. Yet it is very difficult to determine how much advantage is secured from such efforts, owing to the great variation in seasons and in the abundance of weevils in different fields, or even in parts of the same field.

Drought is more effective in holding weevils in check if the dry weather begins before the cotton plants are large enough to provide the necessary food and shelter for the weevils. If the plants continue to make good growth during weather that is too dry for the weevils to propagate, the crop can be set and brought to maturity without serious damage, even in localities where earlier plantings have suffered severely from the weevils. This explains the very great advantage that is generally to be gained in dry regions by plowing the land in the fall and maintaining the tilth through the winter as a preparation for the planting of cotton, in order to have as much moisture as possible available in the soil and thus enable a more continuous growth to be made during any periods of dry weather that may occur in the early part of the growing season.

With proper attention to the preparation of the land, cotton can be grown even without irrigation in many districts of the Southwest that have been looked upon hitherto as hopeless deserts. The drought-resistant qualities of the cotton plant are only beginning to be appreciated, perhaps because the chief centers of production have been located in humid regions. In localities where small supplies of irrigation water can be developed they can probably be used to much better advantage with cotton than with any other crop. The general danger in irrigated regions is the excessive use of water. The chief obstacle to the extension of cotton culture in the Southwestern States is the scarcity and high cost of labor, but the progress that is being made in the invention of cotton-picking machinery indicates that this limitation may be removed in the near future.

IMPROVEMENT OF QUALITY BY CULTURAL METHODS.

Cultural methods that allow a continuous development of the plants may also help to counteract weevil injuries. Interruptions of growth not only invite greater damage from weevils but injure the quality of the fiber. If the presence of the boll weevil can induce the farmer to adopt better methods of culture, better staples can be produced, so that a lessening of the crop may be compensated by an increase in value. To improve the fiber so as to be able to sell small crops for as much or more than the former large crops would be a very practical method of reducing the losses inflicted by the weevils. Reduced production of long-staple Upland cotton in Louisiana and Mississippi is increasing the demand for superior varieties of intermediate lengths, from an inch to an inch and a quarter. These can be grown in many parts of the cotton belt where only short and inferior varieties are now planted.

With the boll weevil as a further obstacle the tendency is for the careless farmer to give up the culture of cotton, but farmers who adopt the other precautions to make cotton profitable under weevil conditions are likely to take the additional step of adopting better varieties and maintaining the uniformity of their stocks by the necessary selection.

Longer and stronger staples could be produced over a large part of Texas if better varieties were grown and better methods of culture were applied, so that the fiber could be properly ripened instead of growth being suddenly checked by drought and the bolls opened prematurely. Even under conditions of extreme drought it is possible to produce fiber of good quality if the plants are not checked. Though plants that develop under dry conditions may remain very small for lack of moisture, they may still produce excellent lint. This was well shown in experiments at San Antonio, Tex., in 1910. A season of continuous drought produced better fiber than the previous year when the drought was interrupted by a rain at the middle of July. The rain allowed a larger growth of the plants, with larger demands for moisture, but no other rains came to maintain the supply. Though the rain undoubtedly increased the crop, much of the fiber suffered in quality because the plants were checked during the fruiting period and the bolls opened prematurely.

In localities where irrigation facilities exist, even a very limited supply of water could be utilized to great advantage in bringing the cotton crop through to maturity. Where water is to be had in the winter, but without facilities for summer storage, winter irrigation may be practiced as a preparation for the cotton crop, the water being retained in the soil by the same methods of tillage as in dry farming. There is an unfortunate tendency in irrigated districts to apply

water to the growing plants too early in the season. The result is to stimulate an undesirable vegetative growth and make the crop late, thus increasing the danger of weevil injuries.

In the drier districts of southern and western Texas the farmer depends more upon the moisture already stored in the soil than upon rain that falls during the growing season. To raise a crop of cotton without any rain on the plants would seem an impossibility in many humid regions, but this can often be done in dry regions if the previous rainfall has been conserved in the soil by proper tillage. Indeed, it is possible to have too much water stored in the soil and thus make the plants too luxuriant, just as it is possible to have too much rain.

Under such conditions there is the less reason to urge the importance of very early planting. In experiments with successive plantings of Triumph cotton at San Antonio, Tex., in 1906, the April and May plantings grew quite as large as the March plantings, showing a practical equality of the available supply of soil moisture, which was the limiting factor in this experiment. The surface of the soil becomes drier as the season advances, so that recourse to previous wetting of the seed or to somewhat deeper planting may become necessary to secure a good stand, but the easier cultivation and greater freedom from weeds in dry weather more than compensate for extra precautions in sowing.

LATER PLANTING IN BLOWING SOILS.

In addition to the loss of moisture and the checking of the plants by weather too cold for growth to be made, early planting increases the danger of the "blowing out" of the seedlings in some of the sandy districts of southern Texas that are otherwise well adapted for cotton. The surface soil may be drifted away and the plants broken down by the wind or the young stems may be actually cut away by the blowing sand. The winds are said to be much more severe as a rule in March than in April, and in districts where this is true it might be better if all plantings could be deferred till the later month. Even though the winds were as severe in April as in March the crop is less likely to be injured if the period of exposure is shortened. It is also easier to keep the soil from blowing before the cotton is planted, by throwing the surface of the field into ridges.

In addition to the possibility of avoiding injury from the wind, the April plantings are likely to have the advantage of more continuous growth. This not only favors an earlier and larger crop, as already explained, but tends at the same time to increase the length and the uniformity of the lint. The proportion of aberrant plants that are likely to appear in a variety of cotton depends to a

considerable extent upon whether the plants are severely checked in the early stages of development or make uninterrupted growth.

LIMITATIONS OF LATE PLANTING.

If whole communities could be organized so that all the cotton could be planted at the same time and all the plants destroyed in the fall, so that none would survive the winter, later planting would become more feasible than at present; but other interests of the crop forbid very late planting.

In the northern districts of the cotton belt it is not safe to shorten the season by deferred planting, and even in places where the season is long enough the habits of the cotton plant set limits to late planting. If the weather is too hot during the early stages, the fertility of the plants suffers through a change in the habits of growth. Fruiting branches are not produced so near the ground as in earlier plantings, but are replaced by more numerous upright vegetative branches. With plenty of moisture such plants become large and bushy and produce a late crop, at the mercy of the weevils. Or if dry weather cuts off the supply of moisture the growth of the late plants is checked before the fruiting stage is reached, so that little or no crop can be set.

Under conditions of drought, the tendency to excessive vegetative growth of the young plants may be restricted by lack of water in the surface soil. This is another reason why late plantings are more likely to be successful in seasons when the drought is severe enough to check the multiplication of weevils. Thus at Palestine, Tex., in the season of 1909, some fields of cotton planted in June, after the harvesting of a crop of potatoes, developed normally and gave larger yields than neighboring fields planted much earlier, in April or May. In a wet season such late plantings might be a complete failure. The fruiting stage would probably not be reached until the weevils had time to multiply and destroy the whole crop.

Varieties differ in the readiness with which their characters are changed in response to differences of cultural conditions, some being more suitable for late planting than others. The tendency to deferred fruiting and to the production of excessive numbers of vegetative branches is still stronger in the Egyptian cotton than in the Upland series of varieties. Early planting of Egyptian cotton has been found necessary in Arizona as a means of controlling the growth of the plants, though no weevils exist.

Planting too late also interferes with the early destruction of the stalks, a most desirable measure for reducing the number of weevils that survive the winter. The earlier this work can be done the more successful it is likely to be, for the principal object is to deprive the

weevils as early as possible of food and of facilities for breeding. If this work is postponed until the plants are killed by frost, much of the advantage of removing the stalks is lost, though it may still be very important to destroy the unripe bolls, which sometimes carry many weevil larvæ through the winter. In some districts the pasturing of the cotton fields in the fall is very useful, for the cattle eat the buds and green bolls with the weevils and larvæ that might otherwise be left in the fields.

Another factor that tends to limit late planting in Texas is the prevalence of root-rot. As the attacks of this disease are often deferred till the latter part of the season, the plants that are killed may not represent a total loss. Some of their bolls may be ripe before the plants are killed, and the remainder are opened prematurely by drying, so that the lint, though often weak and worthless, can be picked and sold with the rest of the crop. In some parts of Texas fields are often seen with half the plants dead from root-rot before the middle of September, though half or three-quarters of the crop may be already mature. If the crop were to be deferred by late planting, root-rot injuries might involve a total loss. In such cases the root-rot, rather than the boll weevil, may be said to determine the necessity for early planting.

RELATION OF DROUGHT TO WEEVIL-RESISTANT HABITS OF GROWTH.

Recognition of the importance of dry weather brings a new factor into the question of weevil-resistant habits of growth. If it be considered a matter of first importance to lessen the number of weevils that go into hibernation in the autumn, it appears to be essential to use the earliest and most determined varieties, so that the crop can be completed at the earliest possible date, and thus leave the weevils without opportunity to breed for as long a period as possible before winter. It happens, however, that some of the best of the early varieties, such as the Triumph cotton of Texas and the Kekchi cotton of Guatemala, have low, compact habits of growth that undoubtedly tend to interfere with the beneficial effects of dry weather in killing the weevil larvæ. Fallen squares are much more effectively shaded by a low, compact plant than by one that bears its foliage farther up so that all of the ground under the plant is exposed directly to the sun during at least a part of the day. Plants that stand well up from the ground and allow the sun to reach and dry out the fallen squares and kill the weevil larvæ are able to secure in this way a distinct advantage over the low, compact plants that shade the fallen squares and protect them from the dry winds.

Many of the experimental plats at San Antonio in 1909 consisted of Triumph cotton. The low, compact form of the plants was well

calculated to shade fallen buds lying under them, though even in such buds the weevils did not appear to prosper under conditions of very extreme drought. But an adjacent planting of a newly acclimatized Mexican type of Upland cotton gave much less shelter for the weevils. No leafy branches were developed at the base of these plants until after fruiting had begun, so that the early foliage was borne well up from the ground.

This Mexican variety had not been supposed to have any specialized weevil-resisting characters, although it had given very favorable results under weevil conditions. The contrast in behavior between this variety and the Triumph was very striking, the Mexican cotton having much less tendency to put out branches from the lower joints of the stem.

Partly as a result of later planting and partly because of its different habits of growth, this cotton continued to develop slowly during the dry weather of May and June and was ready when rain finally came in July to put on very quickly a good crop of bolls. The tendency to ripen all of the bolls at one time has been shown in several other experiments and is to be reckoned as a very desirable characteristic of this type of cotton. It lessens the labor of picking and allows the fields to be cleaned of the old stalks early in the fall.

The behavior of this Mexican type of cotton may be contrasted in many ways with that of the Kekchi cotton from Guatemala. The Kekchi cotton has several definite weevil-resisting adaptations not possessed by the Mexican cotton, such as hairy stems and leaves that restrict the movements of the weevils, large, hairy, well-closed bracts that impede the access of the weevils to the young buds, and long pendent or creeping basal branches, the buds and bolls of which are seldom attacked because of the strong instinct of the weevils to climb up the plants instead of remaining on the lower branches or crawling downward. But in southern Texas, where most of the experiments with cotton have been made, some of the weevil-resisting characters have cultural disadvantages. Although the lower branches often continue to produce buds and bolls long after the weevils have halted all the other types of cotton, the additional bolls are borne so near the ground that they are often soiled by blowing sand or muddied and rotted by rain. Bolls produced underneath the plant often rest on the ground and are also subject to mildew and other diseases. An attempt is being made to avoid these disadvantages by selecting more erect forms of the Kekchi cotton that carry their bolls clear from the ground and thus enable the several desirable features of this type of cotton to be utilized. In addition to the weevil-resisting characters, some of the acclimatized strains of the Kekchi cotton have shown themselves very early and productive, and with lint of good Upland quality.

It is easy to understand that a variety with a rapid-fruiting habit like the Mexican cotton would be even more likely to have definitely determinate growth than an early-flowering variety like the Kekchi. The small size of the plants of early varieties may be ascribed to the fact that vegetative growth is less rapid after fruiting commences and if dry weather ensues an extra early variety may mature and cease to grow even under the same conditions that permit another variety with later fruiting habits to continue its development. Determinate habits of growth, like other desirable things, may be carried to excess. If selection for earliness be directed solely to the question of early flowering or early opening of bolls the effect on yield may be adverse. Very early flowering or very early opening of some of the bolls is not in itself a guarantee of the practical weevil-resisting value of a variety. Varieties that flower very early may develop more slowly or attain a precocious maturity if exposed to dry weather or to other unfavorable conditions that interrupt the growth of the plants.

IMPORTANCE OF DRY WEATHER IN HUMID REGIONS.

In cooler and more humid regions the importance of the drought factor must of necessity decline. Unless the weather is hot and dry enough to interfere with the propagation of the weevil larvæ, the direct advantage secured from drought in a dry climate is not obtained. A humid climate with heavy dews may allow unimpeded development of weevils, even in the absence of rain. Yet there is a very important indirect advantage in a period of dry weather, even though the conditions are not severe enough to destroy the weevils. Too much moisture interferes with the development of the cotton plant, either by stunting its growth or by causing the shedding of buds and young bolls. In a district where there are no weevils such a shedding may do little damage, for the plants continue to produce buds and can soon replace the loss, but with the weevils present the loss of the early crop by shedding becomes a much more serious matter.

In a continuously humid climate the early buds must be expected to furnish the crop, for all the later buds are likely to be destroyed by the weevils. There must be no delay in the development of the cotton if a crop is to be set before the insects become destructively numerous. The closer the race becomes between the cotton and the weevils, the more important it is that the plants lose no time in development and that the crop receive no setback by the shedding of buds or bolls. Every precaution that favors the quickest possible development becomes worthy of careful consideration, such as the planting of the cotton in dry, well-drained soil, thorough preparation and cultivation, and the application of fertilizers.

One limitation must be recognized in all such efforts. It is possible in some regions to stimulate the cotton into an excessive vegetative growth, and thus defeat the object of securing an early crop. If the plants make too rank a growth at first, fruiting is likely to be deferred, the lower fruiting branches being replaced by vegetative limbs.¹

DIFFERENT TYPES OF EARLINESS IN RELATION TO WEEVIL RESISTANCE.

The ideal form of earliness for varieties that are to be grown in humid regions is not extreme precocity in showing the first flowers or the first ripe bolls, but the production of the crop as rapidly as possible after fruiting begins. Even the early varieties are not so early in humid regions as in dry, for abundance of moisture conduces to more vigorous vegetative growth and to the production of vegetative limbs near the base of the plant instead of fruiting branches. In a continuously humid region an early-fruited variety would have no advantage over one that began to fruit a little later unless the later variety were attacked by weevils bred on the early variety, in case both were planted in the same locality.

If all the cotton in a humid district began to bud and blossom somewhat later but had the rapid-fruited habit, it would have two advantages over an early-fruited variety in relation to the weevils. A smaller number of weevils would survive until the late variety began to fruit and the late variety would be able to set the same amount of crop in a shorter period, after it had once begun to fruit. Late varieties that differ from early varieties in completing a larger amount of vegetative growth before they begin to fruit should be able to produce fruit more rapidly after fruiting has once begun.

Rapid fruiting, rather than early flowering or early opening of bolls, represents the most effective form of weevil resistance under conditions of continuous humidity. Other things being equal, there is more reason to expect fruiting to go on rapidly in varieties that begin to bud and flower rather late than in those that flower very early. A variety that begins to flower very early is likely to require more time to produce the same number of bolls than a later flowering variety. The relatively small size of the plants of all the early-flowering types may be taken as evidence that the very early production of fruit tends to check vegetative growth. In other words, earlier flowering may lead to slower fruiting, if account be taken of the total number of bolls or the quantity of cotton ripened within a given period.

¹ See "Dimorphic Branches in Tropical Crop Plants," Bulletin 198, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1911.

A later date in flowering is not to be reckoned as a lessening of weevil resistance if a variety sets its fruits with sufficient rapidity after flowering has begun. Until the flower buds are about half grown the weevils can not begin to reproduce. The rapidity with which bolls are developed within a specified time after the buds are large enough to allow the weevils to begin to breed would serve as a measure of weevil resistance in experiments with varieties in humid regions. It is important to establish such standards and to apply them to all varieties that are to be grown under weevil conditions, whether the weevils are already present or not.

In attempting to determine the rate of setting of the crop in different varieties, special precautions must be used. It is not sufficient to compare the yield in early pickings, for this will give an undue advantage to the factor of early opening in small-bolled varieties. Neither is it sufficient to determine the tendency to fruit production by the daily counting of flowers on experimental rows or plats representing the different varieties. Allowance must be made for the fact that a big-boll variety does not need to produce as many flowers in order to set the same amount of crop in the same number of days as a small-boll variety. Daily countings of the numbers of flowers on adjacent rows of different varieties may also be rendered unreliable by differences in shedding, some varieties dropping their buds and young bolls much more readily than others.

The counting of the full-grown bolls at different dates would give an indication of the crop-setting habits if there were any ready means of determining when the bolls have reached full size. For the most accurate determination it would be desirable to make counts of the bolls as fast as they became large enough to escape weevil injury, though it would still be necessary to take into account the differing amounts of cotton represented by the same numbers of bolls of different varieties.

It may be that the rapidity with which the bolls are opened corresponds to that with which they are set, but there is no definite information on this point. It has been noticed in some plantings of Mexican cotton that the bolls seemed to open more nearly together than those of the Triumph cotton and other United States Upland varieties grown in the same places. The rate of opening of the bolls depends very largely on the weather at the time when the bolls reach maturity, but these experiments were made under dry conditions, with equal opportunities for opening.

It was generally assumed at first that small-boll varieties must have a distinct advantage in weevil resistance because of earlier flowering and earlier opening of the bolls. Large importations of seed of the King and other small-boll varieties from the Carolinas were brought in to replace the Texas big-boll sorts in weevil-infested

districts. Nevertheless, the small-boll cottons have not gained any general popularity in Texas, most farmers having returned to the native big-boll varieties. Additional familiarity with the factors that determine production under weevil conditions makes it possible to understand why the big-boll varieties do not show any such serious disadvantage in weevil resistance as at first expected.

The larger bolls require longer periods for full development, but during most of the time they are beyond the danger of weevil injury. The growth of the bolls continues longer after the crucial stage of weevil infestation has been reached. A big-boll variety that could produce as many flowers and set as many bolls in the same number of days as a small-boll variety could yield a larger crop in proportion to the increased size of the bolls, or larger bolls may make up for a deficiency in the number of flowers. The few observations that have been made do not indicate that big-boll varieties fall very seriously below the small-boll sorts in their rates of flowering and boll setting. The production of flowers and young bolls may not make larger demands on a big-boll variety than on a small-boll type. If the weevils are to prevent any further boll setting after a certain date, a big-boll variety has the advantage of being able to produce more cotton in each of the bolls that reaches maturity.

In districts where the season of growth is very short, early opening of the bolls may be necessary to avoid the danger of frost, but in a large part of the cotton belt the lapse of a few more days before the bolls begin to open is not to be considered as a serious disadvantage and is not likely to outweigh the stormproof qualities, easier picking, and other desirable features of the big-boll varieties. It is quite possible that the Texas big-boll type of cotton may be found less satisfactory in humid regions and that special selection may be necessary under the new conditions to establish local strains with uniform expression of earliness and other desirable characters. In the drier regions of central and southern Texas, where the growth of the plants is usually limited by drought, the same general tendency to early fruiting appears in the big-boll and small-boll types, but greater differences may be shown where more abundant moisture provides for more luxuriant growth.

IMPORTANCE OF RECOGNIZING FACTORS OF WEEVIL RESISTANCE.

Too much stress can be laid upon early varieties as well as upon early planting, because both these factors lose in effectiveness if pushed to extremes. Cotton planted too early may develop more slowly than cotton planted later, and varieties that begin fruiting too soon may take longer to develop a full crop. These considerations are well-nigh self-evident when once pointed out, especially when viewed in relation to the dry-weather factor. If the benefits

exerted by dry weather are ascribed to early planting alone there is danger that the farmer may rely too much upon the date of planting and fail to appreciate the still greater importance of tillage and other means for securing an uninterrupted development of the crop.

That the production of cotton has been maintained in Texas has been taken generally to mean that the weevil menace was exaggerated. This may be true to the extent that the susceptibility of the insect to dry weather was not at first appreciated. In some localities the first seasons of weevil infestation were unusually wet. The destruction wrought by the weevils in the wet seasons was expected to continue every year, and the very existence of the cotton industry seemed to be threatened. At present the tendency is rather to the other extreme of optimism, on the assumption that the same results are to be expected over the whole cotton belt as in Texas. Such reasoning may prove erroneous, especially in regions that are subject to continued rain or damp weather in the early part of the growing season. Continued wet weather is always unfavorable to the cotton crop, no matter how satisfactory the other conditions may be. The losses occasioned by wet weather become the more serious if weevils are present to prevent the setting of any later crop of bolls.

In many cotton-growing districts the soils are so heavy and adhesive that the fields can hardly be entered for two or three days after each rain. In localities where the soils are varied much can be gained by choosing the driest and best drained land for cotton, but rain may still interfere with the cultivation of the fields and prevent the gathering of the weevil-infested squares.

Even in places where good yields can be obtained in favorable seasons the growing of cotton may become unpopular if the crop becomes too precarious. In the more humid sections of the coast belt of Texas, for example, some of the most progressive farmers consider the future of cotton culture as doubtful. Those who have been careful to clear their fields and destroy their stalks early in the fall and give their land good preparation and tillage have found it possible to raise good crops of cotton in spite of the weevils. In other seasons, when too much rain interfered with cultivation and the plants grew too large and shaded the ground before the bolls were set, the crop was seriously reduced or became a total loss. Nevertheless, the prevailing high prices have encouraged the taking of larger chances on the cotton crop, even by farmers who previously declared their intention of abandoning cotton altogether.

EARLIER LONG-STAPLE VARIETIES.

The practical questions of weevil resistance vary in different regions, like other cultural problems. In the Texas short-staple district an immediate advantage was obtained by the use of earlier

short-staple varieties. In long-staple districts the need of earlier varieties is still more acute. The introduction of the early short-staple varieties into the long-staple districts is not calculated to preserve the long-staple industry. There can be little doubt that the difficulty of producing the long staples is increased by the growing of the short-staple varieties in the same neighborhood. More weevils are bred early in the season in the short-staple fields. There is also more danger of admixture of the long-staple with the short-staple varieties, either by cross-fertilization in the fields or by the mixing of seed at the public gins.

Even before the weevils came, the manufacturers complained that the long-staple varieties were deteriorating, because the fiber was becoming less uniform. This has been ascribed to the fact that more and more of the ginning has been done in recent years at large public gins where the seed of the whole community becomes mixed, instead of at the smaller private plantation gins which gave much less opportunity for such admixture. If the long-staple varieties continue to decline in uniformity at the same time that the yield is being cut down by the presence of the weevils, there is less prospect of an ultimate survival of the long-staple industry.

The need of quick-fruited long-staple varieties has been recognized in advance in the cotton-breeding work of the Department of Agriculture. Two such varieties have been developed and distributed, the Columbia cotton, originated by Dr. H. J. Webber, in South Carolina, and the Foster cotton, bred by Dr. D. A. Saunders for the Red River Valley of Louisiana and northeastern Texas. These varieties are not only distinctly earlier, but are also more productive than the older long-staple sorts. In their habits of growth they are much more similar to short-staple Upland varieties and they seem to yield at least equally well. Some of the Columbia cotton raised in the season of 1910 has been reported as selling as high as 24 cents a pound. While this price may be considered exceptional, there can be no doubt that a very general increase in the value of the cotton crop could be secured by replacing the present short and variable stocks with such varieties as the Columbia and the Foster.

The early-maturing characteristics of these varieties give them almost the same advantages of weevil resistance as the early short-staple varieties that are now being grown in former long-staple districts. The chief difference is that prolonged drought is a greater danger to the long-staple crop than to short staples. The difference is not so much in the ability of the plants to withstand dry weather as in the requirement of continuous growth, if uniform length and strength of fiber are to be secured. If the growth of the plants be checked during the fruiting season, shorter and weaker fiber is the result and the whole crop is injured by the lack of uniformity. The

higher requirement of uniformity limits the production of long-staple cotton to districts where the soil moisture is adequate or is supplemented by irrigation. The irrigation facilities being developed in many localities in southern Texas may make it possible to extend the cultivation of long-staple varieties to a new region.

It remains to be seen whether cotton-growing communities can be organized to take full advantage of early long-staple varieties that have been developed. The size of the crop and the uniformity of the product may both be increased if whole communities, instead of scattered individual planters, can devote their time to the production of long-staple varieties. The preservation of the necessary uniformity of the long-staple varieties will become much easier if no short-staple types of cotton are grown in long-staple communities. The deterioration of varieties through cross-fertilization in the field and by the mixing of seed at gins can both be avoided in well-organized communities that limit themselves to one superior variety of cotton.

DIFFICULTY OF DIRECT TESTS OF WEEVIL RESISTANCE.

One of the chief obstacles in the study and general application of the factors of weevil resistance lies in the great difficulty of making any comparative tests that will definitely determine the actual values even of factors that have obvious practical importance. It is not reasonable to disregard these factors because of the difficulties of testing them. Fortunately there is no possible conflict between the cultural methods that are advised for purposes of weevil resistance and those that are calculated to secure maximum production, even without weevils.

In the case of early and late varieties the planting of the two side by side is likely to give an exaggerated idea of the benefits of earliness. It is certainly to be expected that a row of late cotton will suffer much more by being planted next to an early row infested with weevils than if there were no early cotton in the neighborhood. But if the plantings are made in separate fields to avoid the danger of weevils from adjacent rows, the equality of other experimental conditions can not be assured. Differences of yields at the end of the season can not be ascribed with any confidence to weevil differences alone. The soil may differ in fertility or in the content of moisture and cause wide fluctuations of the crop, even in regions that have no weevils. All other considerations are likely to be overshadowed and forgotten when the weevils are at hand. Nor does the use of isolated fields give any assurance of equality in the numbers of weevils. Even in parts of the same field the extent of damage from weevils usually shows wide variations, often 50 per cent and upward, especially in

the early parts of the season before the period of total infestation is reached.

The planting of the two kinds of cotton side by side insures unfair conditions for the late cotton by breeding an extra supply of weevils close at hand. But if the experiment is made in isolated fields the usual inequalities of infestation may give an unfair advantage to either planting.

A field of late cotton planted by itself might appear at no such disadvantage in relation to weevil injury as would be expected from experiments with early and late rows planted close together. As a matter of fact, it often happens that a late-planted field suffers less from the weevils than fields a mile or two away that were planted a month or six weeks earlier.

But as soon as we begin to compare the different fields more in detail it becomes apparent that many other elements may modify our conclusions. More fertile soil or more favorable temperatures that enable the plants to make more rapid and uninterrupted growth may be the cause of a larger yield, instead of any particular factor of weevil resistance that might have been under investigation and that might have very definite importance in another case. In short, the problem of weevil resistance is not to be separated from other complex cultural problems. The factors of weevil resistance have to be studied and applied from the standpoint of the local conditions that determine the choice of varieties and methods of cultivation.

CONCLUSIONS.

The presence of the boll weevil introduces another factor of uncertainty into problems of cotton production in addition to the usual differences of soils and seasons. The effects of special methods of culture and the special characteristics of varieties should be taken into account in attempting to grow cotton in weevil-infested regions.

Weevil-resisting characters and methods of cultivation are more useful in dry regions or in dry seasons, because the propagation of the weevils is less rapid and the weevil-resisting factors are effective for longer periods. In dry regions the same factor that restricts the growth of the plants also tends to prevent the propagation of the weevils. In humid regions, on the other hand, the growth of the plants may be impeded by wet or cloudy weather that does not restrict the propagation of the weevils.

Wet weather not only favors the rapid multiplication of the weevils, but also interferes with the application of cultural expedients for avoiding weevil injury. Even the weevil-resistant characters of earliness, quick fruiting, and determinate habits of growth are likely to

diminish or to disappear when the plants are grown under extreme conditions of heat and humidity.

Smaller injuries from weevils lend a relative advantage in dry regions and in dry seasons. It is not safe to assume that improved cultural methods, earliness of varieties, or special weevil-resisting characters will have the same value in humid regions that they may have shown in dry seasons in Texas. In the absence of the limiting factor of drought, it is not safe to apply the analogies drawn from Texas to the more eastern States.

The problem of weevil resistance is especially acute in the humid bottom lands of Louisiana and Mississippi, the chief centers of production of the long-staple Upland varieties. Every possibility of weevil resistance in the long-staple district is worthy of careful investigation, because special conditions of soil and climate make it possible to produce superior grades not generally obtainable in other parts of the cotton belt.

Earlier maturing long-staple varieties that have been bred in the United States or acclimatized from abroad may replace the present long-staple varieties whose late-maturing habits render them more susceptible to injury by the boll weevil, especially when grown in the same localities with early short-staple varieties.

Two additional measures of weevil resistance are also worthy of careful consideration in humid regions, the development of quick-fruited long-staple varieties and the better organization of cotton-growing communities so that only one type of cotton shall be grown in the same locality.

While the use of early-fruited varieties and the early planting of the crop are important in avoiding weevil injuries, both of these policies have distinct limitations. Very early varieties may be relatively unproductive, and too early planting may check the growth of the seedlings, delay their development, and postpone the fruiting period. The chief object is to secure the most rapid setting of a good crop rather than the earliest opening of flowers or bolls.

The early production of flowers or of ripe bolls does not prove that a variety has the most effective form of earliness for purposes of weevil resistance, especially if this precocious fruiting tends to restrict the growth of the plant. Rapidity of fruiting after fruiting has once commenced is more important than absolute earliness, as shown by the dates of the first flowers or the first open bolls. The setting of a crop of bolls in the shortest time after the flower buds begin to appear is the ideal form of earliness from the standpoint of weevil resistance. This requirement of rapid fruiting should be taken into account in the breeding of weevil-resistant varieties, as well as in devising improved methods of culture for weevil-infested regions.

As the weevils are restricted for food to the pollen of the cotton plant and are unable to begin to breed until the production of flower buds has begun, breeders of new varieties for weevil conditions should consider that plants may gain rather than lose if the formation of fruit buds can be deferred till the roots and other vegetative parts have made considerable progress, especially if this preliminary growth allows the more rapid formation of fruit buds when fruiting has once commenced.

Though later flowering varieties might appear to suffer more from the weevils than the early-flowering varieties if the two were planted side by side, the true agricultural value of a late-flowering variety would not be settled by such an experiment. It is obvious that somewhat later flowering would not be a disadvantage if it shortened the period of setting the crop. Nor would a somewhat later opening of the first bolls be undesirable, especially if there were a tendency for the whole crop to open more nearly together.

The practical value of rapid-fruited long-staple varieties would also be increased if they were planted by whole communities. The exclusion of earlier short-staple varieties might be expected to give the long-staple varieties less exposure to weevil injuries, and at the same time it would help to maintain the uniformity of the crop by avoiding cross-pollination by bees and admixture of seed in public gins.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 221.

B. T. GALLOWAY, *Chief of Bureau.*

DIMORPHIC LEAVES OF COTTON AND ALLIED PLANTS IN RELATION TO HEREDITY.

BY

O. F. COOK,

Bionomist in Charge of Crop Acclimatization and Adaptation Investigations.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., April 28, 1911.

SIR: I have the honor to transmit herewith a paper entitled "Dimorphic Leaves of Cotton and Allied Plants in Relation to Heredity," by Mr. O. F. Cook, Bionomist in Charge of Crop Acclimatization and Adaptation Investigations of this Bureau, and to recommend its publication as Bulletin No. 221 of the Bureau series.

Numerous agricultural applications of the facts of dimorphism have been described in Bulletin No. 198 of this Bureau, entitled "Dimorphic Branches in Tropical Crop Plants: Cotton, Coffee, Cacao, the Central American Rubber Tree, and the Banana." The present paper reports additional information regarding the dimorphic characters and variations of cotton and other plants and points out their relation to problems of heredity and breeding. It is believed that more definite knowledge of the characters and habits of growth of our cultivated plants will be of assistance in many lines of agricultural investigation.

Respectfully,

WM. A. TAYLOR,
Acting Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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DIMORPHIC LEAVES OF COTTON AND ALLIED PLANTS IN RELATION TO HEREDITY.

INTRODUCTION.

Parallel series of variations in the forms of the leaves can be traced through numerous species of cotton and also in other genera of *Malvaceæ*, such as *Hibiscus*, *Abelmoschus*, and *Ingenhousia*. The parallel variations appear as characters of different cultivated varieties and are also represented by dimorphic specializations of leaf forms in different parts of the same plant.

Though this class of variations has received little attention hitherto, the facts are of interest in relation to general questions of heredity and to the practical problems of breeding superior varieties and maintaining their uniformity by selection. Recognition of dimorphism of the leaves and branches in cotton and related plants enlarges the range of characters that may be used in distinguishing varieties and in determining the influence of environment upon the expression of characters.

The cotton plant affords unusually good opportunities for the study of environmental modifications, but it is essential that the characters and habits of the various cultivated forms be well known if the differences of behavior in different conditions are to be correctly understood. Studies of environmental differences or of correlations of characters that do not take into account the normal diversity in the structure of the different parts of the plant may give very misleading results.

Though different kinds of leaves or branches represent very definite facts of heredity, yet the expression of such characters can be influenced by external conditions. Thus it has been found that new conditions may seriously disturb the expression of characters in the cotton plant, even to the extent of a complete suppression of the fruiting branches, so that the plants remain completely sterile, although showing a high degree of vegetative vigor. The behavior of such plants may be compared with that of sterile hybrids. In both cases there is a failure to bring the full series of normal characters into expression.¹

¹ Cook, O. F. Dimorphic Branches in Tropical Crop Plants: Cotton, Coffee, Cacao, the Central American Rubber Tree, and the Banana. Bulletin 196, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1911, pp. 18-27.

For the purposes of the selection that has to be maintained in order to keep a superior stock in a condition of uniformity, it is quite as important to recognize varieties by the characters of their leaves and branches as by those of the bolls and seeds. Indeed, selection by vegetative characters can be made even more efficient than selection by fruit characters because it enables degenerate variations to be recognized and removed early in the season, thus avoiding the danger of spreading inferior characters through cross-pollination.¹

Selection is our means of keeping undesirable characters from coming into expression, but it does not prevent the transmission of such characters. Even though all the lines of descent that show tendencies to the expression of undesirable characters be rejected, the possibilities of such expression remain in the other lines and are likely to be reawakened if selection be relaxed. One of the most important problems in the selective breeding of cotton and other seed-propagated field crops is to make selection more efficient by more adequate knowledge of the characteristics and behavior of the plants, so that deviations from a type can be more easily recognized and removed from the stock and the exciting causes of such deviations avoided.

DIMORPHISM A PHENOMENON OF ALTERNATIVE EXPRESSION.

The most important of the general facts or principles of heredity that may be illustrated by the phenomena of dimorphism is the fundamental distinction between expression and transmission. Unless this distinction is appreciated it is impossible to understand the measures of selective breeding that are required to preserve the uniformity and maintain the agricultural value of superior varieties of cotton and other seed-propagated crop plants. Many efforts are being made to solve the problem of heredity by seeking in the protoplasm of germ cells for microscopic organs or mechanisms that are supposed to transmit the characters from the parents to the offspring. While the discovery of such a mechanism would be of great scientific interest, the facts of heredity that promise to be of most value from the standpoint of agricultural application are facts of expression. Even without determining the mechanism of transmission it is possible to investigate the effects of breeding and environment upon the expression of characters.²

The doctrine elaborated by Weismann that there is a fundamental distinction between the germ plasm and the protoplasm of the somatic or vegetative tissues has doubtless tended to prolong the

¹ Cook, O. F. Cotton Selection on the Farm by the Characters of the Stalks, Leaves, and Bolls. Circular 66, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1911.

² Cook, O. F. Transmission Inheritance Distinct from Expression Inheritance. *Science*, n. s., vol. 25, 1907, p. 911.

confusion of the facts of expression with those of transmission. The phenomena of inheritance have been supposed to center exclusively in the germ cells, the assumption being that all the characters that are to be shown in the adult are determined beforehand in the germ cells. The facts of dimorphism suggest that the phenomena of heredity and breeding can be studied in the vegetative parts of the plants as well as in the floral or reproductive organs or in the protoplasmic mechanism of the germ cells.

The production of a succession of different kinds of internode individuals by vegetative propagation shows that characters may be brought into expression and then suppressed and replaced by other characters without the necessity of new conjugations to form new germ cells. In all the higher plants the expression of the characters is changed repeatedly during the growth of each individual. This may be one of the reasons why the processes of heredity appear to be more susceptible to environmental influences in plants than in animals.

That the leaves and other vegetative parts of many plants do not have the power of regenerating or bringing the characters of the other parts into expression does not demonstrate a fundamental difference between the germinal and somatic protoplasm. In some plants, such as the *Begonia*, it is evident that all of the tissues inherit all of the characters, since new plantlets are able to bud out freely from the leaf blades, petioles, and stalks.

In *Bryophyllum* also young plantlets are produced from the leaves, but only from particular points along the margins instead of from the whole surface of the leaf. But even with the most definite limitations of expression there may be evidences of complete transmission. Thus lateral branches of coffee, though apparently quite unable to produce upright shoots from vegetative buds, are certainly able to transmit all the characters of the species, for all the fruit is produced on the lateral branches.

If there were a complete correspondence between expression and transmission, so that the transmitted characters of a variety could be fully known from a single individual or from a generation of uniform individuals, the characters of a pure-bred uniform variety might be expected to remain fixed for all time and further selection would be entirely unnecessary, as assumed in some theories. But in reality no such permanent uniformity has been found to exist. No refinement of the breeder's art establishes an unchanging expression of characters in any seed-propagated plant, or even in those that are increased by vegetative propagation. It is easy to understand that selected strains of wheat or other plants adapted to self-fertilization may show greater and more permanent uniformity than

varieties of cross-fertilized plants like cotton and corn, but the idea of an absolutely fixed or constant expression of characters does not accord with the facts of biology.

The successive formation of the different organs of the plant represents a series of changes in the expression of the characters, often as definitely contrasted as differences between varieties or species. Even in purely vegetative organs like the leaves specialized dimorphic changes of expression may be established in some species, instead of more gradual or continuously varied changes that appear in related species or even in other varieties of the same species.

In the study of heredity, as in many other fields of scientific exploration, there is a tendency to give special values to evidence drawn from remote or difficult sources and to overlook the significance of familiar facts or of those that are capable of easy and direct observation. Yet it must be recognized that any underlying principles or general facts of heredity that are to be of practical use must have relation to readily visible external characteristics of our most familiar domestic animals and plants. The more familiar the facts, the more ready and reliable should be the interpretation, were it not for the greater interest generally secured by more remote and more doubtful considerations.

Though some of the facts described in this paper may not have been previously recorded in connection with the cotton plant and its relatives, similar facts are common enough in other genera and families of plants. The dimorphic leaves and branches of cotton and other related plants do not represent extreme types of specialization, but this may give them the greater interest from the standpoint of heredity because of the intermediate position between the more definite and less definite forms of alternative inheritance.

It is usual to think of plants as simple individuals, but in reality they are compound individuals built up by the association of many individual internodes or metamers, each of which may be capable of an independent existence. The internode individuals are not all of one kind. In addition to the specialization of some of them as floral organs definite differences are often to be found among the vegetative metamers. The fact that many plants seem to lack definite specializations among the vegetative internodes only renders such peculiarities the more interesting when they occur, for they throw another light on the facts of evolution and heredity.

The development of any individual plant may be viewed as a progressive change of expression of characters, the juvenile characters giving place to the adult, but the changes are generally so gradual as to suggest no analogy with the Mendelian form of definitely contrasted alternative inheritance. Abrupt changes from juvenile to

adult forms of foliage have long been known in such cases as junipers and eucalypts, but these have not been considered as of the same nature as the contrasted inheritance of Mendelian characters. In the case of the cotton and Hibiscus, however, it appears that Mendelian relations exist in characters that are also subject to abrupt change during individual development. Mendelian inheritance is associated with other contrasted changes in the expression of characters. The same characters that show contrasted expression in Mendelian hybrids may be as definitely contrasted, in related plants, in the growth of each individual. Mendelism, like the dimorphic differences, may be looked upon as representing alternative expression of characters instead of alternative transmission.

ABRUPT CHANGES OF LEAF FORMS IN *HIBISCUS CANNABINUS*.

A very pronounced example of dimorphism of leaves was observed in Egypt, in May and June, 1910, in *Hibiscus cannabinus*, the so-called Deccan or Ambari hemp, a plant commonly grown along the borders of cotton fields. The object of planting the hemp with the cotton is to avoid the injuries of the plant lice, which are usually severe on the more exposed margins of the fields. Though the hemp plant is a rather close relative of the cotton, it is much less susceptible to the attacks of the insects and grows up more rapidly. The cotton field is protected against the drier outside air that might otherwise enable the plant lice to destroy the outer rows. Moreover, a bast fiber extracted from the Hibiscus is made into a coarse cordage used for many agricultural and domestic purposes.

Variations of leaf forms in the hemp plant show a curious parallel with cotton. In addition to the entire or very broadly lobed leaves comparable to those of ordinary Upland varieties of cotton, there are other varieties with deeply divided narrow leaves, like the so-called "okra" varieties of cotton in the United States, and some with leaves parted to the base into narrow digitate segments, a condition also known in some of the tropical varieties of cotton. (Pls. I, II, and V.)

Further similarity was found in the fact that the Egyptian variety of *Hibiscus cannabinus* with the lobed leaves produced entire leaves at the base of the stalk, as also happens with the narrow-lobed "okra" varieties of Upland cotton. The Hibiscus leaves show a very abrupt transition from the broad, simple form of leaves on the lower part of the stalk to the narrow, deeply lobed form on the upper part (fig. 1); this abrupt change in the characters of the leaves seemed the more worthy of notice on account of the fact that Mendelian segregation of the broad and narrow forms of leaves has been found to occur in the second generation of crosses between

varieties of cotton representing two corresponding types of leaves. The hemp plants with the two kinds of leaves represent a segregation of characters among the internode members of the same plant.

The leaves of the upper part of the stem are all deeply lobed, while those of the lower part are without lobes. The transition is usually quite abrupt, though the leaves that are close to the transition are often slightly different from others of the same class. A premonition of the change may be found in the larger marginal teeth of the last of the undivided leaves (fig. 2), or the last simple leaf may have a prominent angle on one or both sides (fig. 3). A more definitely intermediate condition appears when a leaf is divided on one side



FIG. 1.—Growing tips of stalks of *Hibiscus cannabinus*, showing changes from simple to lobed leaves. (Natural size.)

but not on the other. (See Pl. II.) In such cases there is usually a very pronounced difference between the two sides of the leaf, so that the change from the entire to the lobed condition is still quite abrupt in comparison with the very gradual changes shown in many plants in passing from the large basal or radical leaves to those of the upper part of the stalk.

Specimens to illustrate the abrupt nature of the transition from the entire to the lobed form of leaf (Pl. I) were taken quite at random, except for the necessity of seeking plants that had uninjured leaves at the nodes where the transition took place. Many of

the leaves were badly mutilated by the bites of insects. It was also necessary to search a little farther to find examples of more gradual transition from the entire to the divided state. (See Pl. II.)

Those who prefer mathematical statements of such facts might measure the depths of the incisions of the leaves and construct curves or other numerical expressions of the differences of form, but the nature of the differences is apparent in the photographic reproductions. It is evident from the abruptness of the transition that curves representing measurements of the divisions of the leaves would show two very distinct and well-separated modes, quite as distinct as those that would represent the expression of contrasted characters in cases of Mendelian segregation in the second generation of a hybrid.

It is difficult to imagine that any practical advantage can be secured by the plants by changing the form of the leaves thus abruptly part way up the stalk. Yet it is possible that the different forms of the leaves may be connected with the fact that there is a difference of function among the internodes of the stalk. The internodes of the upper part of the stalk produce fruit or fruiting branches, while those of the lower part do not. Some of the lower internodes of the cotton stalk give rise to large vegetative limbs with the same functions as the stalk, while other internodes produce only small abortive branches or none at all. Several of the barren internodes usually intervene between the highest of the vegetative limbs and the lowest of the functional fruiting branches, as though it were difficult to change abruptly from one form of branches to the other.

In Deccan hemp and the okra plant the fruits are borne directly at the axils of the main stalk without the intervention of fruiting branches. It may be that the divided leaves indicate in advance the internodes that are to produce flowers and fruit. Change of leaf form marks the approach of the fruiting condition in such plants as *Hedera helix* and *Ficus repens*, but in such cases the change of leaf forms does not occur on the same axis of growth. The creeping stems of the juvenile stage represent an adaptive condition inter-



FIG. 2.—Four leaves from successive internodes of the same stalk of *Hibiscus cannabinus*, showing slight differences among the simple leaves and abrupt change to the divided form. (Natural size.)

calated into the life histories of these plants, like the larval stages of insects.

The joints of the stalk of the cotton plant may also be considered as dimorphic with reference to the two kinds of branches that they produce, but it is a further step in hereditary specialization if the joints prove to be differentiated also by the forms of leaves that subtend the two kinds of branches. The external conditions often appear to influence the number of vegetative branches, but it is not yet known whether such changes are caused by direct transformations in buds already formed or are previously determined in the growth of the primary stalk. It may be that differences in the forms of the leaves will help to show when the characters of the branches are determined.



FIG. 3.—Leaves from adjacent internodes of *Hibiscus cannabinus*, showing transition from the simple to the divided form, but with the lobes indicated in the simple leaf by prominent angles. (Natural size.)

In Upland varieties of cotton the fruiting branches are produced closer to the base of the plant than in the Egyptian cotton, and the seedlings of Upland cotton also begin to produce lobed leaves at earlier stages than Egyptian seedlings. The second or third leaves of Upland cotton often show distinct lobes, and in some varieties, such as "Willet's Red Leaf," even the first leaf may be lobed. In the Egyptian cotton, where the vegetative branches are more numerous and the fruiting branches begin farther up the stalk, the seedlings usually produce from five to seven entire leaves before the lobed leaves begin to appear. In luxuriant plants the vegetative branches continue farther up the stalk than the entire leaves, but under other conditions the vegetative branches are less numerous. Fruiting branches have

been found on the Egyptian cotton in Arizona as low as the seventh node, as reported by Mr. Argyle McLachlan.

LEAF FORMS OF VARIETIES OF *HIBISCUS CANNABINUS*.

At least two varieties of the Deccan hemp are grown in Egypt, one with deeply divided, finely toothed leaves (Pls. I and II) and the other with more coarsely toothed, undivided leaves (figs. 1, 2, 3, and 4). It does not appear that either of these Egyptian varieties has been introduced into the United States, but a third variety with digitately parted leaf blades, not seen in Egypt but supposed to come from India, has been grown experimentally in Louisiana. (Figs. 5 and 6.)

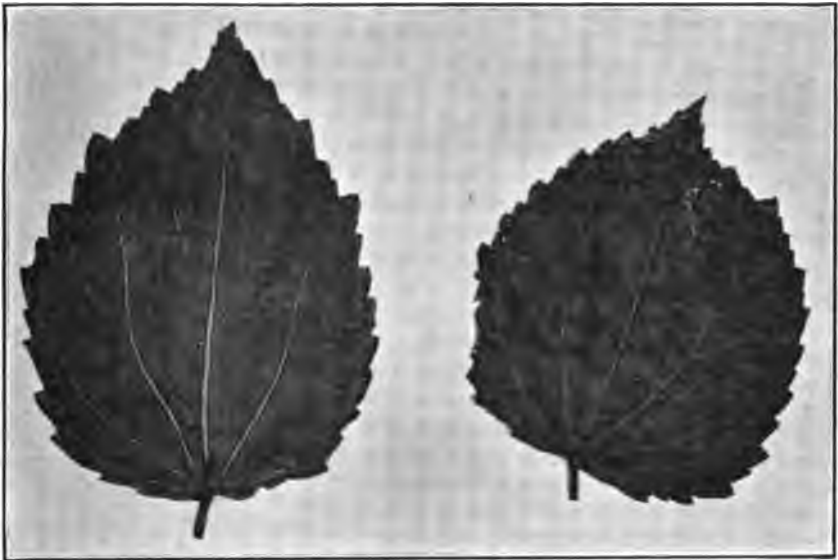


FIG. 4.—Simple-leaved Egyptian variety of *Hibiscus cannabinus*. (Natural size.)

The variety with the dimorphic leaves is much more generally planted in Egypt, but plants with broader, undivided leaves are often found growing with the others. At Tanta, to the north of Cairo, separate plantings of the broad-leaved variety were seen. The plants seemed larger, coarser, and of a darker green color than those of the narrow-leaved type growing in the same locality. The leaves are distinctly larger and with the margins much more coarsely toothed. A tendency to the lobed form of leaf seemed to be indicated in this variety only by the somewhat larger teeth at the ends of the largest of the oblique veins. There may be a general correlation between the shape of the leaf and the size of the marginal teeth. The teeth seem to be larger in the undivided leaves of the

dimorphic variety than in the lobed leaves. The smallest teeth are found on the specimens with the very narrow digitate lobes. (See figs. 5 and 6.)

Examples of transition forms of leaves seem to be more common on plants with rather small, narrow-pointed, sharply dentate leaves than in plants with larger leaves and less numerous teeth. (See Pl. II, A, B, C, and D.) It is not impossible that these differences represent distinct varieties or strains. There is no reason to suppose that the Egyptian varieties of this plant have been subjected to any

more close or careful selection than the Egyptian varieties of cotton, which were found to exhibit a wide range of diversity.

In Hooker's "Flora of British India" the leaves of *Hibiscus cannabinus* are described in two slightly different ways, once "Lower leaves entire, upper lobed," and again "Lower leaves cordate, upper deeply palmately lobed, lobes narrow serrate." The narrow-lobed variety shown in figures 5 and 6 would seem to conform most nearly to this description, though none of the lower leaves are shown in the pressed specimens of this variety in the Economic Herbarium of the United States Department of Agriculture. The species seems not to be represented in the National Herbarium. The leaves of the Egyptian varieties would hardly be described as cordate, though some of those in Plate II show a slight reentrant angle at the base.



FIG. 5.—Three-lobed leaf of narrow-lobed variety of *Hibiscus cannabinus*, grown in Louisiana. (Natural size.)

The lobing of the leaves of the dimorphic Egyptian variety is not unlike that of the plant depicted as *Hibiscus cannabinus* in Roxburgh's "Plants of the Coast of Coromandel" (vol. 2, pl. 190), except that some of the upper leaves are shown with five lobes. Though no such leaves were seen on the Egyptian plants

in July it is quite possible that they occur later in the season. Roxburgh also gives a separate figure of a simple narrowly lanceolate leaf and states that this form occurs at the top of the full-grown plants. According to Wester a similar reduction of the later leaves is shown in the roselle plant (*Hibiscus sabdariffa*).¹

¹ Wester, P. J. Roselle: Its Culture and Uses. Farmers' Bulletin 307, U. S. Dept. of Agriculture, 1907, p. 7. "The leaves on the young plants are entire; as the plant increases in size the leaves change to palmately five parted; later the leaves in whose axils the flowers are borne are three parted."

PARALLEL LEAF FORMS IN COTTON.

The dimorphism of the leaves of *Hibiscus cannabinus* is the more interesting because a closely parallel series of leaf forms appears in the cotton plant. Entire or broad-lobed leaves are found in all varieties of cotton, at least during the early stages of growth, the lobes becoming more pronounced with maturity. (Figs. 7 and 8.) Narrow-leaved varieties of Upland cotton, popularly known as "okra" cotton, show a dimorphism corresponding quite closely to that of the dimorphic-leaved Egyptian variety (fig. 9), and others have a still more deeply divided, strongly digitate form, like the variety of *Hibiscus cannabinus* grown in Louisiana (fig. 10). Young plants of okra cotton have, at first, entire or broad-lobed leaves like the seedlings of other varieties of Upland cotton, but whether the change is gradual or abrupt has not been noticed.

Individual plants with narrow-lobed leaves appear occasionally as mutative variations in broad-lobed varieties. Thus the narrow-lobed leaf shown in figure 9 represents a variety called "Park's Own," said to have originated



FIG. 6.—Five-lobed leaf of narrow-lobed variety of *Hibiscus cannabinus*, grown in Louisiana. (Natural size.)

as a variation of the King variety. (See fig. 8.) Several other mutations have been observed in experimental plantings of the King cotton in Texas showing different degrees of expression of the tendency to narrow lobes.

Transitions from entire to broadly lobed leaves are to be found on nearly every plant of Upland cotton, though entire leaves are more abundant on some varieties. Vegetative branches often have small, entire leaves, like those of young seedlings, on the short basal internodes. The proportion of entire leaves also seems to differ in varieties and is influenced by conditions of growth, humid greenhouse conditions having a distinct tendency to produce more of the entire leaves and to reduce the lobes of the others.

An individual plant of Triumph cotton found in a field at San Antonio, Tex., in September, 1910, showed a marked variation

toward the simple form of leaves. The seed, unfortunately, had all been picked, so that the inheritance of the variation could not be tested. The plant appeared unusually vigorous, but had the advantage of standing at the end of the row. Most of the leaves were simple and entire (fig. 11), only a few being three lobed and these with the lobes unusually short. A count showed 152 simple leaves and 41 with lobes. Some of the wild species of cotton have all the

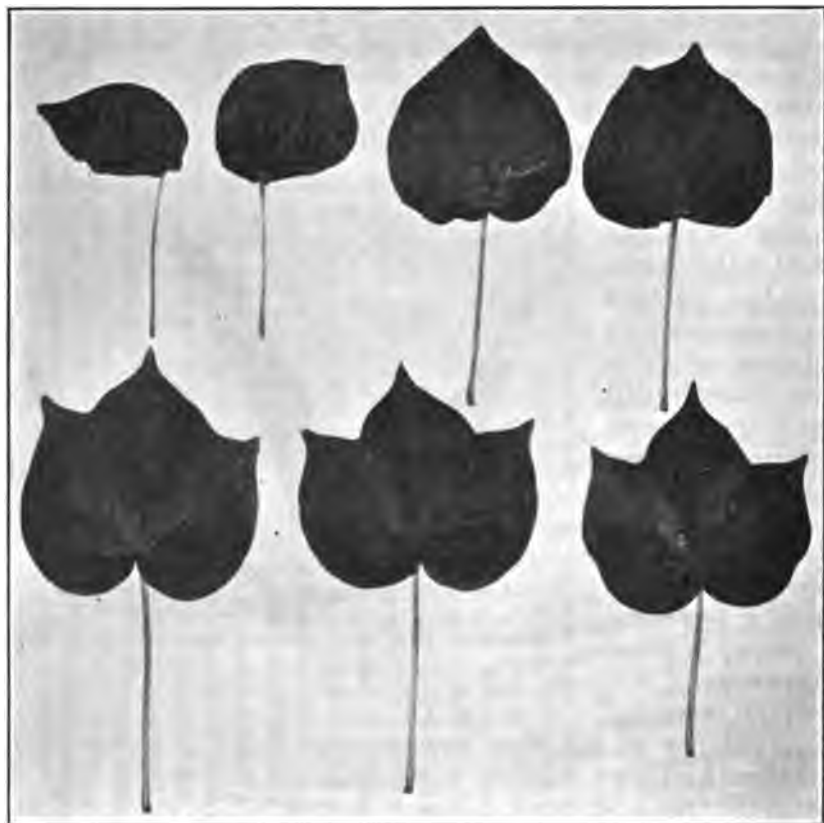


FIG. 7.—Leaves of Upland cotton seedling from first seven nodes above the cotyledons, showing changes of form. (Natural size.)

leaves simple, and thus complete the correspondence with the simple-leaved Egyptian variety of *Hibiscus cannabinus*.

The tendency to reduction of the lobes under greenhouse conditions represents another phase of the general parallelism of leaf forms. This tendency seems to be very general, not only in different varieties of Upland cotton, but also in the Egyptian and Sea Island types that in open-air conditions have the lobes more highly developed than those of Upland cotton. The fruiting branches of green-

house plants of Egyptian cotton have many of the leaves of the fruiting branches quite simple, a character that appears very seldom in open-air plants. A comparison of figure 12 with figure 14 will give an idea of the range of variation in leaf forms on the fruiting branches of the Egyptian cotton and of the extent to which the expression of the characters may be modified by external conditions. It may also be noted that the entire leaf of the Egyptian cotton grown under greenhouse conditions is broader and less pointed than that of the Upland cotton grown in Texas under open-air conditions. As the figure also shows, the texture of the entire Egyptian leaf is much more delicate than that of the Upland leaf, which is not true in outdoor plants of Egyptian cotton.

The greater tendency of the Egyptian cotton to produce entire leaves is also apparent in the early stages of growth. Lobed leaves develop on young plants of Upland cotton from lower joints than in Egyptian cotton, as already noted. Hybrids between Upland and Egyptian cotton, grown at Bard, Cal., in 1911, were intermediate in this respect and usually began to show lobed leaves on the third joint above the cotyledons. The transition from the entire to the lobed form of leaves was much more gradual among the hybrids than in pure Egyptian plants. Very large luxuriant seedlings of the Egyptian cotton, with vegetative branches already pushing from the nodes of the cotyledons, seemed to show less definite transitions in leaf form than the somewhat smaller and more normal plants where the buds in the axils of the cotyledons had remained dormant. Failure of the normal specialization of leaf forms would correspond with abnormalities in the formation of the branches that occur very frequently in the Egyptian cotton under conditions of too luxuriant growth.



FIG. 8.—Mature leaf of "King" Upland cotton, parent of "okra-leaved" variations. (Natural size.)

TWO TYPES OF DIMORPHISM OF LEAVES IN COTTON.

The dimorphism of leaves in *Hibiscus* is of the same type as that of the narrow-leaved "okra" cottons, as already indicated. But there is another type of dimorphism of leaves in cotton, connected with a definite dimorphism of the branches. The leaves of the fruiting branches of cotton are smaller than those of the main stalk and vegetative branches and often have nectaries on only one or two of



FIG. 9.—Leaf of "Park's Own," an "okra" variety of American Upland cotton.
(Natural size.)

the principal veins, even when the leaves of the main stalk and vegetative branches have three nectaries with much regularity.

The dimorphism is not so easily recognized in the blades of the leaves, because of the general freedom of variation in sizes and shapes, but appears much more definite when attention is given to the stipules. On the main stalk and the vegetative branches the leaves have the two stipules equal in size and narrowly lanceolate or strap

shaped (fig. 13), while on the fertile branches of the same plant one stipule may be much broader than the other (fig. 14). Broadening of one of the stipules is a usual and apparently quite normal characteristic of the Egyptian cotton. (Pl. III.) It also appears in a related African type from the Niam Niam, in the upper valley of the White Nile. On the other hand, the enlargement of the stipules and the corresponding reduction of the petiole and blade of the leaf sometimes represents a distinctly abnormal tendency, accompanied by frequent abortion of the flower buds. In such cases the leaves of the fruiting branches become reduced and more or less intermediate in form between the normal leaves of the fertile branches and the involucral bracts that inclose the flower buds. (Pl. IV.)

These abnormal intermediate forms of leaves illustrate the nature of the transformation that has taken place in the specialization of the involucre of the cotton plant. Each of the three bracts that compose the external involucre represents a leaf with the blade much reduced, the petiole entirely suppressed, and the stipules greatly enlarged and united with the blade. In the abnormal intermediate forms of leaves a reduction of the petiole and blade is usually accompanied by a corresponding increase of the stipules, though one is generally much larger than the other. (Fig. 15.)



FIG. 10.—Leaf of "Ratteree's Favorite," an "okra" variety of American Upland Cotton. (Reduced.)

In contrast with the other leaves of the plant, the bracts might be considered as an extreme case of dimorphism, since the differences of form are much greater than those of the different types of foliage leaves. The occurrence of the intermediate forms between bracts and foliage leaves is also quite rare. Under some conditions of growth such intermediate forms seldom or never occur, but under other conditions, or at the end of the season, the normal specializations of

inheritance seem to relax and the abnormal intermediate forms begin to appear. They are much more common in the Egyptian cotton than in the Upland and have shown themselves most frequently in a peculiar fastigiate variety of the Egyptian cotton introduced into Arizona under the name of "Dale," perhaps the same as the variety called "Bamieh" in Egypt.

Other series of abnormalities serve to connect the outer involucre of the cotton flower with the inner involucre, or so-called calyx, as though

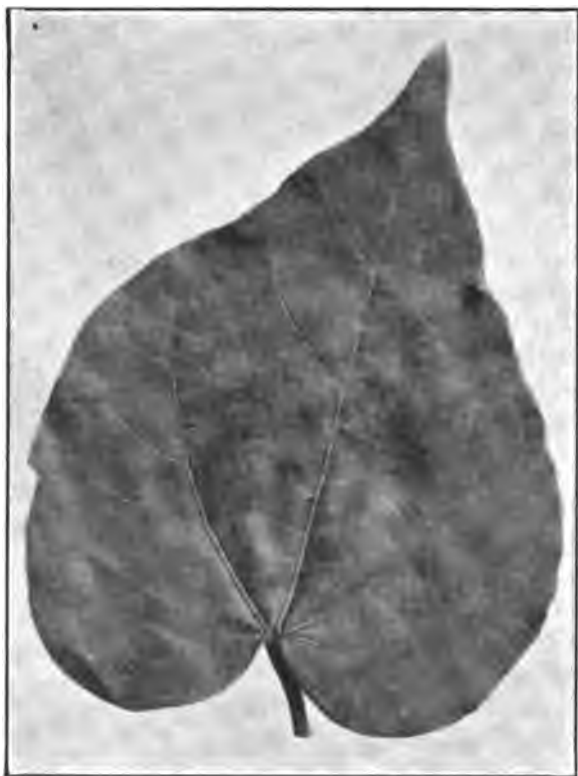


FIG. 11.—Cotton leaf without lobes, a variation of the Triumph variety.
(Natural size.)

this organ were formed from another type of reduced and specialized leaves. The petals, on the contrary, seem to represent specialized stamens rather than specialized leaves. They are inserted on the base of the staminal column. Their development from stamens is also suggested by the small, expanded, petal-like organs that are sometimes found on the staminal column above the true petals. In such a case the petals or the stamens might be said to be dimorphic, or it might be considered that there has been a failure of the normally complete change in the expression of the characters in passing from the petals to the stamens.

PARALLEL LEAF FORMS IN OKRA.

The similarities of variations of leaf form in cotton and Deccan hemp do not exhaust the series of parallelisms. The okra plant (*Abelmoschus esculentus*) also shows the same general range of forms of leaves. Some varieties have broad leaves with very short, rounded



FIG. 12.—Simple leaf of fruiting branch of Egyptian cotton, produced under greenhouse conditions. (Natural size.)

lobes; others have rather narrow lobes, separated to below the middle, and there is a third type with very narrow segments digitately divided to the base. Though attention has not been paid to the

nature of the transition from broad to narrow leaves, it is probable that varieties differ considerably in this respect, for Mr. W. R. Beattie informs the writer that broad-leaved varieties will sometimes show a few deeply divided leaves late in the season. Two general types of pods are recognized, but there seems to be no very definite relation between the form of the leaf and that of the pods. Long, narrow pods are not confined to narrow-leaved varieties, but



FIG. 13.—Young leaf from vegetative branch of Egyptian cotton, with five lobes and equal stipules. (Natural size.)

are shared by broad-leaved sorts. Broad-leaved varieties seem to produce the thickest pods, but some of the narrow-leaved sorts have short pods.¹

The prevalence of the broad-leaved forms of okra in Egypt is doubtless the explanation of the fact that the name Bamieh or

¹ Beattie, W. R. Okra: Its Culture and Uses. Farmers' Bulletin 232, U. S. Dept. of Agriculture, 1905. pp. 12-16.

"okra" cotton is given in Egypt to a variety having unusually broad and heavy leaves, the direct opposite of the variation to narrow-lobed leaves that characterizes the so-called "okra" cottons of the United States. The occurrence of broad-leaved varieties in Egyptian cotton corresponds to the narrow-leaved variations in Upland cotton. The normal foliage of the Egyptian cotton is of the same general form as some of the narrow-leaved or "okra" variations of the Upland type of cotton.

There is a popular idea in Egypt that the Bamieh or broad-leaved type of Egyptian cotton originated from natural crossing of cotton with okra, the same explanation that is given for narrow-leaved variations of Upland cotton in America. The Egyptian Bamieh cotton also produces all of its bolls close to the main stalk, like the okra plant. American Upland varieties of the "okra" type do not have this short-branched habit.

The parallelism of leaf characters between cotton and okra extends even to the presence of a distinct red spot at the base of the leaf at the junction with the petiole. The presence of such a spot on the leaves of a cotton plant is reckoned in Egypt as a distinctive character of the inferior Hindi type that is responsible for a serious deterioration of the Egyptian stock. The leaves of the Hindi cotton are also a distinctly lighter shade of green than those of the Egyptian cotton, matching the color of the okra leaves very closely. These similarities are doubtless responsible for another popular theory, that the Hindi contamination of the Egyptian cotton is due to crossing with the okra plant.



FIG. 14.—Young leaf from fruiting branch of Egyptian cotton, with three lobes and unequal stipules. (Natural size.)

The presence of the red basal spot in the okra and other relatives of cotton is of interest from the standpoint of heredity, in view of the fact that this character shows a somewhat contrasted or Mendeloid expression in hybrids of Egyptian with Hindi or Upland varieties. The contrasting variations of color are not confined to the hybrids, but may appear in the different stages of the same plant.¹

Varieties of okra with the intermediate or narrow-lobed leaves seem to be most common in the United States, but in Egypt, where this crop is much more important than with us, broad-leaved varieties are grown almost exclusively. Okra, as well as *Hibiscus cannabinus*, is commonly planted with cotton in Egypt; but usually to take the place of hills of cotton that have failed to grow, instead of being confined to the borders of the fields.

The only narrow-lobed okra plants noticed in Egypt were a few near Medinet, in the Fayum Oasis. Very little of this variety was said to be planted. The fruits are considered more delicate, but are smaller than those of the broad-leaved plants. In the narrow-lobed variety there was an abrupt change from the broad-lobed



FIG. 15.—Leaf of fruiting branch of Egyptian cotton, with abnormally reduced blade and enlarged, bractlike stipule. (Natural size.)

leaves of the lower part of the stem to the adult form of leaves, but even the broad-lobed leaves were more deeply divided than those of

¹ Cook, O. F. Mutative Reversions in Cotton. Circular 53, Bureau of Plant Industry, U. S. Dept. of Agriculture, March, 1910, p. 10.

a broad-lobed variety included in the same planting. In the latter the lower leaves were almost entire, as often occurs in broad-lobed types of cotton.

SIGNIFICANCE OF PARALLELISM IN THE STUDY OF HEREDITY.

The parallel series of leaf forms of cotton and related plants are of interest in connection with many problems of heredity and breeding. In view of the fact that the same wide range of diversity in leaf forms exists in *Gossypium*, *Hibiscus*, and *Abelmoschus*, it becomes easier to look upon such differences as within the usual range of variation for this group of plants. Changes of characters to wider or narrower leaves do not require us to believe that a new character has originated or that hybridization with a different type of cotton has occurred.

The theory of hybridization as a cause of diversity of leaf forms is rendered the more unnecessary because the wide range of leaf differences appears not only in the same species or variety, but on the same individual plant. This is well shown in a wild relative of cotton, *Ingenhousia triloba*, native in Arizona. (Fig. 16.) The young plants have entire and broad-lobed leaves, while the leaves of adult plants have long narrow lobes. The branches of *Ingenhousia*, grown under greenhouse conditions, do not show the same tendency as in cotton to return to simple leaves, but the three-lobed leaves at the base of the branches have very short and broad lobes, quite unlike the tapering long-pointed lobes of subsequent leaves of the same shoot. The upper leaves have five lobes, as in cotton, okra, and *Hibiscus cannabinus*.

The fact that a wide variation in leaf forms occurs on the same individual plants in primitive wild species makes it entirely unneces-



FIG. 16.—Plant of *Ingenhousia triloba*, showing transition from entire to deeply divided leaves. (Reduced.)

sary to resort to the idea that variations in such characters in cultivated stocks must be due to previous hybridization. Some writers consider that uniform expression of characters, as in a carefully selected line-bred variety, represent the normal condition of heredity, and assume that this condition is found in wild species. The diversities that appear through variation are ascribed to hybridization, to the disturbing influence of the environment, or to mutative transformation into new species. Yet diversity is always found among the members of wild species as soon as the observer gains sufficient familiarity. The uniformity found in "pure-bred" varieties is an artificial product established and maintained by selection. The inferior variations that appear in selected strains of Upland cotton show the same range of diversity that is found among the members of primitive, unselected stocks. Such variations may reasonably be considered as reversions.

The return of latent characters to expression should not be looked upon as rare or exceptional, but as a normal phenomenon of heredity. Uniform expression of characters is rare and exceptional because the tendency to reversion is so general and persistent. Transmission is permanent, not variable like expression. Characters that have been suppressed for thousands of generations, like the incisor teeth of cattle, continue to be transmitted. Students of embryology recognize permanence of transmission by the law of recapitulation. The development of the embryo of a higher animal does not take a straight course from the egg toward the adult form, but remains closely parallel with the courses followed in lower groups. Many primitive characters are brought into slight or temporary expression, though they may disappear entirely before even the embryonic development is complete.

In view of the continued transmission of primitive characters, the tendency of the diversities of the wild types of cotton and other plants to reappear in selected varieties is more easily understood. In a diverse, unselected type each individual inherits and transmits from its many ancestors a large number of characters that are not expressed in its own body, and this transmission of latent characters continues even in the most carefully selected variety. Though opposed by selection, the natural tendency to alternation in expression also continues and becomes effective in the occasional individuals that show mutative variations.

It is true that examples of mutative reversion are usually not frequent enough to affect statistical investigations of other forms of expression of characters, but they are of essential importance in many questions of heredity and breeding. If the possibility of reversion and suppression of characters be left out of account, every definite

change of characters must be considered as the production of a new elementary species.

Mutative departures of occasional individuals from the characters of the parent stock are not uncommon in cotton, and differences in the forms of the leaves are one of the most readily distinguishable types of variation. Most of the variations that produce small bolls can be recognized in advance by their smaller and narrower leaves, or by other differences of vegetative characters.¹

RELATION OF PARALLELISM TO CLASSIFICATION.

The importance of recognizing the fact of a general parallelism of variation in leaf form running through the different types of cotton and related plants is shown also in the field of classification. The genus *Gossypium* contains a large number of locally different forms of cultivated cotton, as well as numerous wild types. The classification of these into species and varieties is a difficult task of systematic botany. Failure to recognize the parallelism of variations has allowed the possession of narrow leaves to be taken as a sufficient proof of relationship. Narrow-leaved forms that are probably quite unrelated have been associated in the same species, while broad and narrow leaved forms of the same type of cotton have been treated as distinct species. These difficulties are well illustrated in a most elaborate monograph on the classification of cotton by Sir George Watt. The okra-leaved variations of American Upland cotton are repeatedly referred to in this work and add not a little to the complexities of the system of classification. Indeed, they are treated quite differently in different parts of the book and are even assigned to different botanical species.

The first suggestion is that the American okra-leaved forms represent a variety of an Asiatic species, *Gossypium arboreum*. This variety is alleged to have been introduced into North America at an early date and afterwards discarded from cultivation, as the following statements will show:

It was not until well into the seventeenth century that we possessed any trustworthy evidence of the Asiatic cottons having been carried to the New World. The Levant cotton (*G. herbaceum*) was the first to be taken to the United States and grown in Virginia. The Indian cottons (*G. obtusifolium*, various races) were conveyed to the States by the East India Co., and the Chinese and Siamese cotton (*G. nanking*) was carried by the French colonists to Louisiana about 1758. *G. arboreum* proper does not seem to have been successfully acclimatized anywhere in the New World, though the most important Asiatic (? hybrid) form derived from that species (*G. arboreum* var. *neglecta*) was early carried to America and the West Indies by the East India Co., and is known in the United States to-day under the name of "Okra" cotton.

There can thus be no doubt that Indian cottons were at an early date introduced into the West Indies and into the United States of America as well, and therefore

¹ Cook, O. F. Cotton Selection on the Farm by the Characters of the Stalks, Leaves, and Bolls. Circular 66, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1910.

very possibly this particular form, as also the far-famed Dacca cotton, stands every chance to have been carefully investigated in the New World. But the fact that *G. arboreum* var. *neglecta* has preserved in the United States, during probably close on 300 years of cultivation, identical characteristics to those it possesses under the widely different environment of India, argues strongly against the structural peculiarities by which it is recognized being viewed as merely geographical and climatological features, that change or disappear under altered conditions. * * *

But with reference to the survival of this presumably Indian plant in America and elsewhere (after its cultivation had been abandoned), it may be observed that once a particular species or race of cotton had been introduced into a favorable cotton-growing country, even though its regular cultivation might chance to be discontinued, it would be no great stretch of imagination to believe that a specially hardy stock, such as the present plant, might survive for centuries. * * * The fact, however, remains that *G. arboreum* var. *neglecta* has been repeatedly recorded as met with in the United States of America, and in the examples seen by me the plants in question could not possibly be separated botanically from the corresponding Indian stocks.¹

It has not been found possible to produce hybrids between our American Upland varieties and the Asiatic species, though large numbers of experiments have been made in both India and the United States. In view of the failure to produce hybrids the Asiatic cottons can not be considered as close relatives of the American Upland type, though they show the same general range of variations of leaf forms. That the close similarity of leaf form should have led Watt to refer an American Upland cotton to an Asiatic species may be considered as a further testimony to the complete parallelism of variation.

Another okra-leaved variation of Upland cotton was considered by Watt to represent a hybrid of *Gossypium punctatum* or *G. hirsutum* and *G. schottii*, the last being a new species described by Watt as a wild plant in Yucatan. The idea that the narrow-leaved condition could be reached as a "natural sport" or mutative variation from a broad-leaved variety like the King is tacitly rejected in the following paragraph:

G. schottii, as defined by me above, must of necessity be a wild plant, since its inferior grade and low yield of wool would never justify its cultivation. It, however, matches sufficiently closely a hybrid found in a field of King's Improved cotton at Richmond, Va. (recently sent to me by Mr. Lyster H. Dewey of the Bureau of Plant Industry in the United States of America), as to countenance the belief that the so-called sport in question may have originated through the hybridization of *G. punctatum* or of *G. hirsutum* with the present species. The specimen came to me under the vernacular name of *okra*—a name that it will be recollected had on a former occasion been given to an American sample of *G. arboreum* var. *neglecta*. It is suggestive of the West Indian name *ochro* (*Hibiscus esculentus*) and possibly thus denotes the deeply dissected condition of the leaves. From the remark on the attached label of the present specimen it may be inferred that the American authorities were induced to believe that, though widely different from King's Improved, it was per-

¹ Watt, G. The Wild and Cultivated Cotton Plants of the World, 1907, pp. 81, 101, and 102.

haps but a natural sport. "Thousands of plants were grown from the seed, and but very few reverted to the broad-leaf type."¹

In a later paragraph of the discussion of *Gossypium schottii* still another interpretation of the okra-leaved variations is proposed:

The bulk of the Upland American stock of present-day cultivation might be described, and accurately so, as consisting of forms of *G. mexicanum*. We read that repeated fresh supplies of seed have been procured direct from Mexico. It would thus be no great stretch of imagination to assume the possibility of hybridization of the cultivated stock of Mexico with the Yucatan *G. schottii* or some other allied form. Hence it is quite probable that King's Improved may itself be a hybrid of this nature, the split-leaved plant which appeared as if a saltatory variation being a recessive manifestation of the *G. schottii* characteristics. It is equally possible, however, that the fresh seed, imported from Mexico, may have been mixed and that the split-leaved plant had survived in the States for some years (and even got hybridized there) before its presence was recognized, just as the "Hindi weed cotton" of Egypt is reproduced year after year. In fact it might be possible to be a cultivated state of *G. schottii* in which no hybridization existed whatever, a weed of not sufficient importance to attract attention, which, once mixed, the seeds could not very readily be picked out from the supply reserved for future sowings.

If the narrow-leaved variations were a result of recent importations from Mexico they might be expected to appear more frequently in the Texas big-boll type of cotton and other varieties that Watt assigns to *Gossypium mexicanum* than in the King and other eastern small-bolled varieties that Watt holds to be more related to *Gossypium punctatum* and *G. hirsutum*. In reality the okra-leaved variations seem to be confined to the King and other small-boll types. They are certainly very rare in the big-boll varieties, if they occur at all.

For American readers it is hardly necessary to add that the theory of the existence of *Gossypium schottii* or any other wild type in the cotton-growing districts of the United States is not known to have any warrant of fact. There is a wild cotton in southern Florida, perhaps the same as that which has been described from the West Indies as *Gossypium jamaicense*. A specimen recently received from Mr. T. Ralph Robinson, collected by Mrs. Robinson on Terraceia Island in the lower part of Tampa Bay, indicates that the wild cotton of Florida extends farther to the north than has been supposed hitherto. Yet it would be a mistake to assume that it represents a close relative of our cultivated Upland varieties. The petals are yellow and have purple spots like those of the Egyptian or Sea Island cottons, instead of the white, spotless petals of the Upland varieties.

As a further example of the extent to which parallelism of leaf form may confuse classification, mention may be made of a curious, small-bolled, narrow-leaved cotton found by Messrs. G. N. Collins and C. B. Doyle at Tuxtla Gutierrez in southern Mexico, under the vernacular

¹ Watt, G. Op. cit., p. 207.

name "Culluche." The species has not been definitely identified, but Mr. F. L. Lewton suggests that it may represent Todaro's *Gossypium microcarpum* variety *rufum*. The leaves of the Culluche cotton are extremely variable in form, and many of them are quite simple.



FIG. 17.—Simple leaf of Culluche cotton from Tuxtla Gutierrez, Mexico. (Natural size.)

But instead of being broadly cordate like the simple leaves of Upland or Egyptian cottons, the simple leaves of the Culluche cotton are fusiform or lanceolate, much like the abnormal leaves of the Egyptian cotton shown in Plate IV and text figure 15. One of the simple leaves of the Culluche cotton is shown in figure 17. Comparison of this with the illustrations of the Egyptian cotton previously mentioned will show how close a resemblance of leaf forms may arise in species of cotton that are widely different in other respects.

RELATION OF DIMORPHISM TO MUTATION.

Viewed as a phenomenon of heredity, dimorphism of leaves presents an analogy with mutative variation. The fact that the abrupt change or contrast of characters occurs in the same individual plant instead of in separate plants should increase the interest attaching to such variations, especially if it appears that they are of the same general nature as the mutations that give rise to new varieties.

The change of characters involved in the production of dimorphic leaves has the most direct analogy with the rather rare phenomenon of bud mutation. Cases are known in which the expression of characters is changed in a single bud of a tree. A single branch of a tree shows a definite peculiarity not

found in other branches or other trees of the same variety. A bud mutation of coffee seen in Guatemala some years ago had leaves as definitely unlike the remainder of the tree as any of the numerous seminal mutations of coffee that had been previously studied.

The most obvious difference between such a variation and the dimorphic branches and leaves of coffee, cotton, or cacao lies in the fact that the bud mutations are of rare and irregular occurrence, while the changes of characters shown in dimorphism are regularly repeated during the development of each individual plant or tree. The production of fertile branches in the cotton plant involves a mutative change of characters away from those that are expressed in the main stalk and the vegetative branches. But instead of producing normally only the one kind of branches with rare mutations to other kinds, the regular course of development for the cotton plant involves the production of two forms of branches, the vegetative form near the base and the fertile form farther up the stalk. In the Triumph variety of Upland cotton there may be said to be a double dimorphism, resulting in three forms of branches. The internodes of the lower fruiting branches are very short, like those of the branches of "cluster" varieties, though branches with internodes of normal length are produced farther up.

De Vries has proposed to associate bud variations with the form of alternative expression of characters shown in accommodations to external conditions (dichogeny). Accommodations and mutations are alike in the general sense that both may be considered as phenomena of alternative expression, but the changes of expression are evidently determined in different ways in the two cases. Bud variations represent definitely determined changes in the expression of the characters, like seminal mutations, but in the condition of dichogeny there is no such definite determination of expression on the part of the plant. Changes of expression continue to be dependent on the external conditions and are readily reversible if the conditions are changed.

The analogy between bud variations and dimorphic branches is much stronger, for both of these changes of expression are determined by the plant instead of depending on changes of environment and after the changes are made they are not readily reversible. It is also to be noted that all the three kinds of changes of expression shown in accommodations, dimorphism, and bud mutations take place during the processes of vegetative growth without any apparent relation to the special organs of the germ cells that have been supposed to control the process of heredity.

For purposes of the study of heredity a very definite distinction is to be made between changes of expression of characters that arise by mutation and those that appear in response to differences of external conditions. The increase in the proportion of simple leaves on cotton plants grown under greenhouse conditions is not the same,

from the standpoint of heredity, as the variation toward simple leaves in an individual plant of Triumph cotton growing under field conditions, as already described on page 17. In the latter case the simple leaves were not induced by the external conditions, or the effect was limited to a single individual that must be supposed to represent an unusually susceptible condition. And in such cases of individual variation the change of expression is much more definite and permanent than when the change is shared by a whole series of plants or by plants of different kinds. The production of simple leaves on fruiting branches of Egyptian cotton in the greenhouse represents a general tendency to reduction of lobes manifested in many kinds of cotton under such conditions.¹

This distinction does not turn, primarily, on the amount of difference or the extent of the change of expression, but upon the manner and permanence of the change, and the same is true of the changes of expression that constitute the phenomena of dimorphism. The result in both cases is the production of entire leaves; but one case probably represents a definite mutative variation, the other a readily reversible environmental accommodation. Dimorphism and bud mutations may also appear to accomplish the same result, in that two definitely different kinds of branches are produced on the same plant, but in the mutation the change is permanent, whereas the dimorphic changes belong to the series of regular alternations, though maintained by the plants themselves instead of being induced by changes of external conditions.

The substitution of vegetative limbs for fertile branches, as often occurs in the cotton plant, indicates that the external environment is a factor in modifying expression even in distinctly dimorphic characters, though it is not definitely known whether increase of vegetative branches results from the formation of a different kind of buds in the first place or represents a transformation of buds that had a previous tendency to produce fruiting branches. There are indications that both kinds of changes occur, depending on the time when the external conditions are changed. Although the normal course of development follows regular steps it is often influenced profoundly by external conditions, even with respect to characters that are known to be subject also to mutative changes of expression, such as the "cluster" character in cotton. The occurrence of mutative variation has also been found to be influenced by external conditions, mutations being much more numerous in some localities than others, in fields planted with the same selected stock of seed.

¹ Attention has been called by Mr. T. H. Kearney to the fact that similar modifications in oak leaves growing in shaded positions have been pointed out by Brenner in a paper on "Climate and Leaf in the Genus *Quercus*." *Flora*, vol. 90, 1902, pp. 114-180.

The two kinds of leaves borne by the two kinds of branches of the cacao tree, for example, are probably much more different than any mutations that have ever been reported. Changes of expression in dimorphic specializations are as great as or greater than in those that give rise to distinct mutative varieties or sports. Dimorphism not only covers at least an equal range of variation, but affects the same kinds of characters as mutative variations. This is shown very definitely in the Upland type of cotton, where cases of okra cottons with dimorphic leaves arise as mutative variations from broad-leaved varieties. The dimorphic condition, at least in such cases, has to be looked upon as a direct product of mutative variation.

Another form of mutation, more common in Upland cotton than mutations to narrow leaves, is the shortening of the internodes of the fruiting branches, as in the so-called "cluster" varieties. This variation also has relation to dimorphism. The shortening of the internodes of the branches, which characterizes the "cluster" varieties, affects only the fruiting form of branches. The vegetative limbs of "cluster" cottons grow quite as long as those of other varieties. The expression of the cluster character is accompanied by the expression of the other characters of the fruiting branches, like the peculiarities that come into-expression in only one sex of an animal though capable of transmission through the other sex. Breeders consider that special egg-laying or milk-producing qualities are transmitted by male animals as well as by females.

A further analogy between mutations and dimorphic changes of expression of characters may be found in the fact of coherence. Dimorphic branches do not differ in one character alone. One form of branch differs from another in all of its parts. A whole group of characters clings together, as it were, in expression. In a similar way a mutative change usually involves a large group of characters. The fact of coherence is of practical importance in relation to selection, for it enables mutative variations to be much more easily recognized than if each detail of structure or color were free to change independently. In dimorphism, as well as in Mendelism and mutation, there seems to be a tendency to contrasted expression instead of to blended or graded expression. In other words, these phenomena may be said to be free from the law of regression enunciated by Galton. Contrasted characters not only maintain themselves in expression, but the contrast gains reinforcement by combination with other alternative characters.

When hybrids are made between different species, such as the Upland and Egyptian cottons, it becomes evident that some characters have much more freedom of combination than others. For

example, the purple spot at the base of the petal of the Egyptian cotton may appear in plants which otherwise bring only Upland characters into expression. But the expression of the yellow color of the petals of the Egyptian cotton depends very closely upon the predominance of Egyptian characters in other parts of the plants. Egyptianlike hybrids often have white flowers, but Uplandlike plants with yellow petals are of very rare occurrence and are usually infertile or otherwise abnormal.¹

RELATION OF DIMORPHISM TO MENDELIAN INHERITANCE.

Dimorphic leaf characters seem to have the same intimate relations with Mendelian inheritance as with the phenomenon of mutation. Indeed, this might be expected from the fact that characters that appear as mutations generally show Mendelian inheritance when crossed with other varieties not affected by the same mutation.

The leaves that follow each other on the same stalk of a plant of Deccan hemp are as definitely different as those that appear on different plants in the second (perjugate) generation of crosses between broad-leaved cottons and narrow-leaved "okra" varieties. A cross of this kind between a narrow-leaved mutation of King and a Texas variety called Edson has been studied by Dr. D. N. Shoemaker and found to represent an ordinary case of Mendelism. In the first or conjugate generation the leaves were quite uniformly intermediate, while the perjugate generation showed all three types of leaves—broad-lobed, narrow-lobed, and lobes of intermediate width like those of the conjugate generation. Deviations from the Mendelian proportions were not greater than could reasonably be ascribed to the effects of cross-fertilization.²

Hybrids between another broad-lobed Upland variety of cotton (Keenan) and an "okra" variety (Ratteree's Favorite) have been made by Mr. H. A. Allard in Georgia in connection with his experiments to determine the extent of natural crossing. Photographic illustrations of the leaves of the parent varieties and the conjugate hybrid are shown in Plate V, from some of Mr. Allard's specimens kindly furnished for this purpose. All of the plants of the conjugate generation, 84 in number, had leaves of intermediate form. The behavior of the characters in the perjugate generation has not been reported, but Mr. Allard states that a definite segregation of the parental leaf forms was shown.³

¹ Cook, O. F. Suppressed and Intensified Characters in Cotton Hybrids, Bulletin 147, Bureau of Plant Industry, U. S. Dept. of Agriculture, April, 1909, p. 16; and Hindi Cotton in Egypt, Bulletin 210, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1911, pp. 28-33.

² Shoemaker, D. N. A Study of Leaf Characters in Cotton Hybrids. Proceedings of the American Breeders Association, vol. 5, p. 116.

³ Allard, H. A. Preliminary Observations concerning Natural Crossing in Cotton. American Breeders Magazine, vol. 1, 1910, p. 247.

As the illustrations of the leaves of *Hibiscus cannabinus* have shown, the transition from the entire to the divided leaves is not equally abrupt on all plants, but neither is it usual for the two types represented in a Mendelian progeny to have the contrasted characters equally expressed in all individuals. Narrow-leaved mutations from the broad-leaved varieties of cotton are not all equally narrow leaved, nor do the narrow-leaved members of a series of perjugate hybrids all have leaves with lobes of the same width. The range of variation in the perjugate generation is not only vastly greater in total extent than in the first or conjugate generation, but also seems to be greater among the perjugate plants that represent the narrow-leaved group. It is to be expected, however, that these general differences in the range of expression will also be found to vary in different hybrid combinations, just as there may be differences in the abruptness of the transition from one type of leaves to the other in different varieties.

In progenies raised from the seed of okra-leaved mutations grown in fields of the parent variety and subject to natural crossing, both broad and narrow leaves appeared, rather than leaves of intermediate form. Thus the progeny of a narrow-leaved mutation grown by Dr. Shoemaker at Waco, Tex., in 1906, showed the narrow-lobed type of leaves in only about a quarter of the plants, the remainder appearing to be normal broad-leaved examples of the King variety. The progeny of another okra-leaved mutation of the King, selected at San Antonio, Tex., in 1907 and tested at the same place in 1908, showed 20 plants out of 34 with broad leaves, 13 plants with leaves like the parent mutation, and 1 plant with a more extreme expression of the narrow-lobed tendency, as though another mutative step had been taken.¹

The second type of dimorphic leaves in cotton, that connected with the dimorphism of the branches, is similarly related with Mendelian inheritance as well as with mutative variation. Branch characters show Mendeloid expression of characters in hybrids, as well as leaf characters. Crosses between cluster and noncluster cottons of the Upland type do not manifest the cluster habit in the conjugate generation, but the cluster character returns to definite expression in the perjugate generation.²

The interest of the dimorphic leaves of *Hibiscus cannabinus* in relation to Mendelism is to show that a change of characters quite as extensive and abrupt as those that characterize Mendelian hybrids

¹ Cook, O. F. Local Adjustment of Cotton Varieties. Bulletin 159, Bureau of Plant Industry, U. S. Dept. of Agriculture, September, 1909.

² Cook, O. F. Suppressed and Intensified Characters in Cotton Hybrids. Bulletin 147, Bureau of Plant Industry, U. S. Dept. of Agriculture, April 7, 1909, pp. 22-23.

may take place in adjoining internodes of the stalk of the same individual plant. There can be no question, in such a case, regarding the separate transmission of the units of the two contrasted characters to different plants. The same plant not only inherits both of the contrasted characters, but brings them both into expression. Such facts may be considered as additional reasons for believing that Mendelian inheritance may be looked upon as a phenomenon of alternative expression of characters. It no longer seems necessary to predicate an alternative transmission of characters, as often assumed in the study of Mendelism.

That the phenomena of Mendelian inheritance are of much significance in the study of heredity need not be questioned, but what the significance may be is still in doubt. It is possible to interpret the facts of Mendelism in at least two very different ways. The mathematical relations of Mendelism are equally well explained, whether ascribed to an alternative transmission of contrasted characters or to alternative expression. Neither transmission nor expression is understood in its essential nature—that is, as a physiological process—but this only makes it the more desirable not to confuse the two processes in attempting to understand them. The importance of distinguishing between expression and transmission is not so obvious, perhaps, as long as investigation is limited to cytological and statistical studies of typical cases of Mendelism, but collateral evidence of other kinds should not be neglected. On this question plants seem to afford better evidence than animals because of their habits of growth by the vegetative multiplication of internodes. Among the internode members of the same plant body there can be no question of differences of transmission, yet definitely contrasted expression remains the rule of development. Not only are there abrupt transitions from one class of internodes to another, but the tendency to contrasted expression is accentuated by dimorphic specializations within the same class.

DIFFERENT TYPES OF DIMORPHIC SPECIALIZATION.

If the internodes of plants be thought of as individuals, the definite differences that exist between the various kinds of internodes of the same plant appear closely analogous to the contrasted characters of the sexes of the higher animals or the several castes that compose the highly organized colonies of bees, ants, and termites.

Species that are composed of two or more sexes, castes, or other distinct kinds of individuals have been called “ropic,” a term that denotes a definite tendency to contrasted expression of the characters,

as though the relations that determine the expression of the characters had a definite polarity or repulsion so that the contrasted extremes of a series are manifested rather than the intermediate degrees. Arropic species, on the other hand, are composed of individuals of only one kind, manifesting individual variations, of course, but with no definite tendency to the contrasted forms of expressions shown in sexual or dimorphic characters.¹

On the basis of these distinctions the cotton plant and its relatives would be reckoned as arropic species, since there is no sexual or other differentiation into distinct types within the species. At the same time it is obviously desirable to have a ready means of designating different forms of structural specialization in plant individuals whether they belong to ropic or to arropic species. Plants that show obvious differences of leaves and flowers are sometimes called heterophyllous or heteranthous, but these terms record merely the fact of diversity, which is often indiscriminate or intergraded, without any definitely established tendency to contrasted expression of characters.

For the designation of cases of definite dimorphic or polymorphic specialization the word "ropic" may be used in combination with other terms to indicate the part affected. Thus the variety of *Hibiscus cannabinus* with the definite dimorphism of the leaves may be described as phylloropic. Cotton, coffee, cacao, and the Central American rubber tree (Castilla) may be described as cladoropic, since they all show definite specialization of two or more forms of branches. Cacao and some varieties of cotton are phylloropic as well as cladoropic, for the two types of vegetative branches are accompanied by definitely different types of leaves, which do not appear in coffee. According to Went², Castilla also has two kinds of leaves.

The banana plant and the Indian corn are familiar illustrations of a dimorphic condition of the flowers and may be termed anthoropic, each plant bearing two definitely different kinds of flowers. A more complicated case of specialization of floral differences appears in the Central American rubber tree. The male or staminate individuals bear only one kind of flowers, but the female or pistillate trees bear two kinds, each pistillate inflorescence being subtended by two small staminate inflorescences, not of the same form as those that are found on the purely staminate trees. The species as a whole shows a definite specialization of the sexes, but the female trees may be described as anthoropic because of the two definitely different kinds of flowers.

Many terms are used by students of plant pollination to indicate whether the stamens and pistils are present together in the same

¹ Cook, O. F. Aspects of Kinetic Evolution. Proceedings of the Washington Academy of Sciences, vol. 8, 1907, p. 369.

² Went, F. A. F. C. Der Dimorphismus der zweige von *Castilleja elastica*. Ann. Jardin Botanique Buitenzorg, vol. 14, pp. 1-17.

inflorescences, separated in different flowers of the same plant or on different plants, or whether these organs are alike or different among themselves or ripen at the same or at different times. Yet these terms do not indicate whether the different conditions arise by gradual changes in the expression of the characters or whether the other floral parts are different, as well as the stamens and pistils.

Technical terms can often be avoided in describing the details of structure or behavior in any one species or genus of plants, but they become a practical necessity in the scientific task of comparing and contrasting the behavior of different types of plants. Distinctions need to be carefully drawn so as to recognize as definitely as possible the different kinds of diversity that arise because of the different ways in which the expression of the characters is determined. In some cases it is plain that the external conditions are able to influence the expression of characters during the development of a branch, while in other cases determination of characters of branches and leaves seems to be entirely independent of the environment. It is desirable, therefore, to review briefly the terms that have been applied by morphologists to the structural diversities that most nearly resemble the present cases of dimorphic leaves and branches.

Goebel refers to upright shoots of conifers and similarly specialized trees as orthotropes, and lateral or horizontal shoots as plagiotropes; he also considers that the specialization of the lateral shoots (laterality) is of two kinds, called "labile induction" when the lateral branches are able to assume the functions of uprights, as in *Picea*, and "stabile induction" when such substitutions can not be made. There is also a distinction to be drawn between two kinds of "stabile induction" of laterality. In some cases the lateral branches are readily able to regenerate upright shoots from lateral buds, as in cotton, while in other cases the lateral branches seem to have no power of replacing the uprights, even from latent buds. This extreme type of specialization shown in coffee, Castilla, and cacao has also been demonstrated by Goebel in *Phyllanthus lathyroides*.¹

The terms clinomorphy and anisophylly have been used by Wiesner for adaptive modifications of leaf forms connected with differences of position or exposure, but not in relation to dimorphism or contrasted expression of characters as a definite fact of heredity.²

¹ Goebel, K. Einleitung in die Experimentelle Morphologie der Pflanzen, 1908, pp. 86-88.

² In Biologie der Pflanzen, Vienna, 1889, Wiesner states: "Many formative processes in plants are induced by the inclination of the organs to the horizon. All phenomena of development induced through position, not explainable through the effects of gravitation alone, should be comprehended under the name clinomorphy. Clinomorphy appears if an organ in the course of its development is so inclined to the horizon that one can distinguish an upper and an under side, and consists in the fact that the upper half takes another form than the lower." (P. 28.)

"Anisophylly is only an inequality of the foliage of the shoot in relation to position and is shown in the under leaves of a shoot becoming larger and heavier than the upper." (P. 33.)

Goebel considers Wiesner's definition of anisophylly too narrow, and would include cases where the leaves on the under side of the shoot are smaller than those on the upper side, as the following statements will show:

By anisophylly we mean that leaves of a different size and of different quality appear on the different sides of plagiotropous shoots; the leaves which stand upon the upper side are usually smaller than those upon the under side, but the converse is also sometimes the case. * * * All the examples have this in common, that the anisophylly occurs exclusively upon plagiotropous shoots and that it is a *character of adaptation* which has an evident relation to the direction of the shoot and especially to its position with regard to light. * * * Herbert Spencer in 1865 first directed attention to the anisophylly of lateral shoots in plants with decussate leaves, as well as to the connection of the anisophylly of higher plants with external factors, especially with light. * * * The term has come to us from Wiesner, although his definition, which is as follows, is too narrow: "I mean by anisophylly that the leaves lying upon the upper side of prone shoots have smaller dimensions than those upon the under side, whilst the lateral ones are intermediate." We know, however, that the leaves on the under side may be smaller, as is the case in the foliose *Jungermanniæ* and in *Lycopodium complanatum*.¹

An excellent example of anisophylly is found in the common paper mulberry (*Broussonetia*), as shown in figure 18. Indeed, *Broussonetia* may be said to combine two phenomena, for in addition to the distinctly smaller size of the leaves that arise from the upper side of the branch there is a wide range of diversity in the forms of the leaves, which constitutes heterophylly.

Anisophylly is to be considered as a physiological phenomenon, rather than morphological. The inequalities in the size of the leaves are supposed by Wiesner and Goebel to arise by direct accommodation to the position in which they happen to be formed. An accident to a tree that changes the position or exposure of a growing shoot affects the condition of anisophylly by rendering the leaves more or less unequal than they otherwise would have been. Yet the interpretations that have been placed upon anisophylly do not seem to be altogether consistent. In some cases it is considered that the larger size of some of the leaves is connected with better exposure to light, but in *Broussonetia* it would seem that the light must be supposed to restrict growth, for the smaller leaves are produced from the upper side of the branch. Some writers look upon the small leaves as specially adapted to fit in among the large ones and thus utilize all the surface of exposure. In this view *Broussonetia* would seem to have overshot the mark. Figure 18 indicates that much

¹ Goebel, K. *Organography of Plants, Especially of the Archegoniata and Spermaphyta*, pt. 1, 1900, pp. 99-100.

Additional cases of anisophylly in tropical plants from the Malay region have been reported by Heinricher in a paper that concludes with a list of several other papers on the subject. (See Heinricher, E. *Beiträge zur Kenntnis des Anisophyllie*, *Annales du Jardin Botanique de Buitenzorg*, sup. 3, pt. 2, 1910, pp. 649-664, and pl. 25.

more space is lost between the rows of small leaves and the large ones than between the leaves in the rows.

When a definite dimorphism exists the differences in the leaves or branches are not merely physiological, but morphological. There are two kinds of leaves or of branches, not merely two conditions of the same kind. Anisophyly presupposes only one kind of leaves, but with a wide range of accommodation to external conditions.



FIG. 18.—Lateral branch of the paper mulberry (*Broussonetia*), with leaves unequal in size (anisophyly) and diverse in form (heterophyly). (Reduced.)

Inequalities of leaves due to differences of exposure to sunlight may be considered as a weaker form of the same kind of accommodation shown in amphibious plants that produce either an aquatic or an aerial form of foliage, depending on the medium in which they happen to grow.

A term that has a more definite signification from the standpoint of heredity is dichogeny, defined by De Vries as follows:

I mean [by dichogeny] all those cases where the nature of an organ is not yet decided during the early stages of its development, but may yet be determined by external influences. Thus, under normal conditions the runners of the potato plant form at their tips the tubers, but on being exposed to light, or when the main stem has been cut off, they develop into green shoots. * * *

In such cases it is clear that the possibility of developing in either of two different direc-

tions is dormant in the young primordia. For this very reason I should like to apply the name *dichogeny* to this phenomenon. And it evidently depends upon external influences what direction is taken. Therefore, a selection must take place from among the available hereditary characters of the species, and this selection may be influenced by artificial interference. For the theory of hereditary characters such experiments are therefore of the highest interest.¹

¹ De Vries, H. *Intracellular Pangenesis* (translated from the German by C. Stuart Gager, Chicago), 1910, pp. 15-16.

The phenomena of dimorphism of leaves and branches show a general contrast with the phenomena of dichogeny, since they appear to arise from a definite polarity or determination of expression or nonexpression of certain characters that may not be subject to change through the influence of external conditions. In such cases as the dimorphic branches of coffee, cacao, and the Central American rubber tree (Castilla), it is evident that the nature of the organ is definitely predetermined even in the earliest stages of its development. From a bud in a certain position on the internode only one kind of a branch can arise, while another kind of branch comes quite as regularly from another bud in a different position. The lateral or fruiting branches not only do not transform themselves into vegetative limbs but may even be unable to produce new vegetative shoots from buds. In the cotton plant vegetative shoots can be regenerated from axillary buds of the fruiting branches, but in coffee the fruiting branches can produce only inflorescences or other fruiting branches. The same is true of Castilla, except that the fruiting branches nearly always remain simple. In the cacao tree two kinds of branches are even more definitely specialized in their vegetative characters and functions, though both kinds bear inflorescences.

The word "ropogeny" may serve as a general term to cover such cases of definitely predetermined alternative expression of characters resulting in dimorphism or polymorphism in the branches, leaves, or flowers of the same plant. Ropogeny is to be contrasted with dichogeny, in which the expression of the characters is not definitely determined in the early stages but remains subject to change by environmental influences during the development of the plant.

Dichogeny and ropogeny, used in these senses, are strictly physiological terms. One of the problems in the physiology of reproduction is to understand, as far as possible, how the characters are determined and brought into expression. It is evident from the facts of dichogeny and ropogeny, as well as from the general nature of the processes of development in plants, that expression is differently determined in different plants and even in different parts of the same plant. Not only is there a general distinction to be drawn between transmission and expression of characters, but different forms of alternative expression have to be recognized.

The extent to which expression has been modified by specialization does not appear to have any direct relation to the method of predetermination of the characters. In some cases all gradations may be traced between normal foliage leaves and minute bracts or bud scales, while in other cases there are definite differences between two kinds of large, expanded foliage leaves as shown in the cacao tree and still more strikingly in the related species *Theobroma bicolor*.

These facts may explain why some of the more definite but less striking differences have been overlooked, notwithstanding the attention that has been given to the study of the more reduced and apparently more specialized forms of leaves.

In addition to bud scales and prophylla, special names have been given to the reduced leaves of underground shoots (kataphylls) and to those that subtend flowers or inflorescences (hypophylls), but these terms seldom, if ever, refer to examples of definite dimorphic differences like those that sometimes exist among true foliage leaves, nor do they serve to distinguish gradual changes of characters from those that are more definite and abrupt.

It is convenient to use a general term (hypophyll) to cover all forms of reduced leaves, since nearly all plants have such leaves, in addition to the true foliage leaves (trophophylls) and the floral leaves (anthophylls). Most hypophylls are formed by the reduction or suppression of the blade and petiole of the leaf, while the sheath or the stipules are retained or enlarged, as in the involucre bracts of the cotton plant. Both the hypophylls and anthophylls may be disregarded in the study of differences among the true foliage leaves.

The terms that have reference to various kinds of differences among the leaves and branches of the same individual plant may be summarized briefly as follows:

Heterophylly, a general term covering all kinds of diversity of leaf forms on the same plant without regard to whether the differences are definite or adaptive.

Clinomorphy, a general term for differences of form arising through oblique or horizontal position.

Laterality, a general name for special characters of lateral branches as distinguished from those of an upright trunk or branches.

Anisophylly, inequality of leaves on upper and lower sides of horizontal or oblique shoots, as in *Broussonetia*. (See fig. 18.)

Hypophylly, the production of rudimentary or reduced leaves, including prophylls, bud scales, bracts, and other less common conditions, such as the scale leaves above the cotyledons of seedlings of *Persea gratissima* and *Citrus trifoliata* and those near the ends of upright shoots of *Theobroma cacao*.

Phylloropy, production of two or more definitely different kinds of foliage leaves on the same plant, as in the cacao tree and in narrow-leaved varieties of cotton, okra, and *Hibiscus cannabinus*.

Cladoropy, production of two or more definitely different kinds of branches on the same plant, as in cotton, coffee, cacao, and Castilla.

Cladoptosis, the self-pruning habit or spontaneous falling off of specialized temporary branches, as in *Populus*, *Quercus*, and Castilla.

Heteroblasty, the production of a distinct type of juvenile foliage as in *Eucalyptus*, *Juniperus*, *Pinus*, *Hedera*, and *Ficus*.

Homoblasty, the absence of a distinctive juvenile form of foliage.

Dichogeny, expression of characters not completely determined in early stages, allowing different characters to come into expression as a result of accommodation to different conditions, as in *Solanum tuberosum*, *Ranunculus aquatilis*, etc.

Ropogeny, expression of characters completely determined in the early stages, not subject to modification by differences of external conditions, as in the fruiting branches of coffee, cacao, and *Castilla* that are unable to regenerate vegetative shoots.

RELATION OF DIMORPHISM TO SEXUAL DIFFERENTIATION OF PLANTS.

Abrupt changes of characters during the development of plants are not limited to these more or less exceptional cases of dimorphic specialization of different kinds of leaves. Even where the leaves are all of one type numerous changes in the expression of characters are required to form the different kinds of floral organs. This requirement of numerous changes of characters during the process of development renders the phenomena of heredity in the higher plants somewhat different from those that are shown in the higher animals, especially when viewed from a physiological standpoint.

The fact that many of the higher plants are self-fertilized is often taken to mean that the principle of sexuality is less important with plants than with animals, but this idea represents only a partial view of the facts. The pollen grains and ovules of plants are not only as definitely differentiated as the sex cells of animals, but they are produced by plant individuals that have a sexual differentiation quite as definite as that of the higher animals.

The plant individual is constituted in a different way from the individual animal, being made up of a large number of internodes or joints often capable of independent existence, if cut apart, or even provided with natural means of separation. In other words, the plant is to be considered as a compound individual or social organization of numerous internode individuals. The stamens and pistils also represent separate members of the series of internodes that make up the compound plant body.

The process of conjugation in plants involves the union of sex cells derived from different individuals, no less than in animals. Self-fertilization simply means that crossing is confined to germ cells produced by members of the same plant colony. The close association of stamens and pistils in the same flower should not be allowed to conceal the fact that these two types of organs are entirely unlike,

not only with respect to their products of pollen grains and ovules, but in other characters. The same freedom of change and contrast of characters apparent in the external visible features may be supposed to exist in internal characteristics of the germ cells.

Plants that produce both stamens and pistils in the same flowers are often described as hermaphrodite, but this normal bisexual condition should not be confused with an abnormal, partial, or intermediate expression of the characters of both sexes in the same individual, as sometimes occurs among sexually differentiated animals. In normally bisexual plants, on the contrary, the characters of both of the sexes are fully expressed in the separate individual members of the colony. Abnormal hermaphroditism, like that of animals, is shown in plants in the rare cases of malformed organs intermediate between stamens and pistils. The abnormal organs heretofore mentioned (p. 22) as intermediate between stamens and petals represent a similar failure of complete change in the expression of contrasted characters, as also occurs in abnormal intermediate forms of branches.

Morphologists may object that the higher animals, as well as the higher plants, have a segmental or metameric structure in the sense that their bodies are made up by the union of structural elements corresponding to the more distinctly segmental bodies of the lower groups of animals. But whatever stress may be laid upon this idea from the standpoint of morphological theories, it is evident that the physiological differences are profound, involving different relations among the primitive segments and different requirements for changes in the expression of the hereditary characters during the processes of development. The processes of heredity, as shown in the formation of the segments, might be described as simultaneous in animals and successive in plants.

The segmental growth of the animal body is determinate at a very early stage, long before the growth in size is completed. In the higher animals the determinate condition is shown most definitely in the female sex, the whole complement of ovules being formed while the animal is still in an embryonic stage of development. In bees and related insects the male sex is more determinate than the female. The plant body, on the other hand, begins with only one or two segments and adds the others gradually during the process of growth. The individual stamen or pistil of a plant is determinate, but most plants can produce an indefinite succession of stamens and pistils as well as of vegetative internodes.

Plants grow chiefly by successive additions of segmental units. The striking fact about the successive additions of new structural units to the plant body is that they are not all alike but are capable

of very abrupt and very extensive changes of characters. After forming, it may be, several kinds of vegetative internodes, the young plant begins suddenly to make floral or reproductive internodes, each kind of internode involving a practically complete change of characters. The idea that plants could produce the slight changes of characters shown in bud mutations has seemed highly improbable to those who have not witnessed such changes, though more extensive changes regularly take place in the development of each plant.

Beginning with the formation of cotyledons or seed leaves, the plumule of the embryo has already provided for an abrupt change to the ordinary form of leaves. Some seedlings show more gradual transitions from the cotyledons to the ordinary leaves, and some have specialized reduced leaves between the cotyledons and the ordinary foliage leaves, as in *Persea gratissima* and *Citrus trifoliata*. The cacao tree often produces similarly reduced scalelike leaves on many internodes near the ends of the upright shoots in addition to two kinds of functional leaves, the ordinary leaves of the upright shoots being different from those of the lateral or whorled branches. Many plants have small entire leaves like those of seedlings at the base of each new shoot, as in the vegetative branches of cotton. In grasses and palms the basal joint of each branch or inflorescence bears a small bladeless sheath, called the prophyllum, similar to the first leaves of seedlings. Pines, junipers, and eucalypts have a distinct juvenile type of foliage in young plants that entirely disappears in adults, though it is recalled to expression when growth is forced from dormant buds after severe cutting back.

Many herbaceous plants have the so-called radical leaves at the base of the stalk much larger and of a very different form from those farther up, a condition that doubtless passes by numerous gradations into the more definite types of dimorphism shown in *Hibiscus* and *Gossypium*.

The erect fruiting branches of the English ivy are upright and bushy and have more rounded leaves than the familiar creeping stems. De Vries has shown that the so-called variety *arborea* represents merely rooted cuttings of the fruiting branches that continue the upright habit of growth. De Vries also found that the seedlings of such a plant were of the usual creeping form, and came to the conclusion that the upright habit was "not inherited." He states:¹

In 1893 I sowed the berries of an older plant of this kind, in this case an ivy bush of about 2 meters, and obtained over a thousand seedlings. These still grow in our garden and have made, up till now, exclusively creeping stems and branches. The *arborea* form is evidently not inherited.

In the same way it might be said that the characters of butterflies are not inherited, since they do not appear in the caterpillar stage

¹ De Vries, H. *The Mutation Theory*, 1909, vol. 1, p. 44.

of the progeny. Or beards might be considered as not inherited because they are not developed in children. In all such cases there is a temporary latency or postponement in the expression of characters, but no failure of inheritance in the sense of transmission. The adult characters remain latent during the larval or juvenile stages, and the juvenile characters are suppressed in turn during the adult stages. In the development of each individual plant several such changes in the expression of the characters are regularly required for the formation of the different kinds of vegetative and reproductive organs.

In the cotton plant six different forms of leaf organs may be recognized, the cotyledons, the entire or broad-lobed leaves at the base of the stalk, the more divided leaves farther up, the smaller, narrower leaves of the fruiting branches, and the two still more reduced and specialized forms that compose the outer and inner involucres. To form the petals, stamens, and pistils requires three other changes of characters, making nine changes altogether during the course of development of each plant.

The familiarity of the facts makes an adequate appreciation difficult, but if the individuality of the internodes and their method of development, one after another, be recognized, it becomes plain that the changes of characters that take place during the growth of the plant are much more profound than those that are required in the postembryonic development of an animal. The whole complex of characters expressed in one internode individual may give place to the expression of an entirely different complex in the very next internode. Without any opportunity for new conjugations, segregations of characters in different germ cells, or changes in the numbers of chromosomes, one complex of characters after another is called into expression and the previous complex retired to a latent condition.

Failure to effect the full change of expression results in the development of abnormal organs of intermediate form, as in the case of abnormal intermediate branches in the cotton plant. Such branches are usually sterile, or their flower buds are abortive, as in abnormal hybrids or hermaphrodites. The power to complete the various alternations in the expression of the characters determines the possibilities of development in the individual plant, in the same way that the evolutionary progress of a species is determined by evolutionary changes of characters.

The phenomena of alternative expression have been studied largely from the standpoints of environmental modifications and diversities in hybrids. These groups of phenomena are only a small part of the field of alternative expression, which includes also the endless changes of characters that appear during the ordinary processes of

development. Even evolutionary changes appear to depend largely upon the power of alternative expression. After a character has once been acquired transmission seems to be permanent. Characters that are discarded from expression are not dropped from transmission, but may be transmitted in latent or rudimentary form for thousands of generations, as the facts of recapitulation and reversion have shown. The transmission of latent characters should not be considered as a rare or exceptional phenomenon, but as the normal, universal condition.

The internal agencies of the cells, that determine the expression of characters, remain active and capable of profound readjustments during the life history of each individual plant. The changes of characters shown in mutative variations are considered as very important phenomena of heredity, and yet they are far exceeded by the changes that regularly take place during the development of every normal plant. Even the metamorphoses of insects hardly constitute such profound modifications of form and structure as the differences among the internode members of the same plant.

Though the facts of plant development seem to afford little ground for the application of Weismann's idea of a fundamental distinction between the germ plasm and the somatic tissues, a distinction is at least to be made between the processes of inheritance in plants and animals. The unknown internal mechanism that controls the expression of the characters evidently remains in a much more active state during the development of a plant than in the case of an animal. This consideration may help to explain the generally recognized fact that the characters of plants are much more readily modified by changes of environment than those of animals. A recent writer has proposed to explain the greater adaptability of plants and lower animals to changes of environment by framing general laws of diminishing environmental influences in passing from lower to higher groups.¹

A study of the methods of reproduction and development followed in the various groups may reveal biological facts underlying this generalization. The higher animals, that show the least susceptibility to environmental modification, not only have a more nearly simultaneous determination of the expression of the characters, but their warm-blooded bodies are able to maintain constant temperatures and thus protect themselves against the fluctuations of heat and cold that represent one of the most disturbing factors in the development of plants.

Consideration should also be given to the possibility that the sudden and complete changes of characters involved in the production of the

¹ Woods, F. A. *Laws of Diminishing Environmental Influences*. Popular Science Monthly, April, 1910, p. 313.

different kinds of internodes may influence the germ cells and the process of conjugation. The phenomena of sexuality are closely connected with contrasted expressions of characters. Sexuality is primarily a physiological fact, and only secondarily morphological. The physiological value of sexual differentiation must be sought finally in a greater efficiency of the process of conjugation.

In the higher groups of plants and animals there is a double differentiation of sexual characters. The male and female germ cells not only become more and more unlike as the scale of organization is ascended, but sexual inequalities also become more and more developed in the organisms that produce the two kinds of germ cells. Not only the inequalities of the germ cells but also the sexual differentiation of the parent organisms must be supposed to relate in some unknown manner to an increased efficiency of conjugation. Many of the secondary sexual characters of plants and animals are like dimorphic differences in having no direct or obvious use in relation to the external environment, but they may have relation to the internal functions of heredity. Even if considered as mere reflections or anticipations of divergent tendencies of expression embodied in the germ cells, secondary sexual characters would still have physiological significance as showing the fundamental tendency toward alternative expression of characters.

In view of these and other indications that diversity and alternative expression of characters among the members of species have physiological functions in increasing the efficiency of reproduction, it becomes reasonable to consider the possibility that the series of sudden and complete changes in the expression of characters involved in the development of the successive types of internode individuals in plants may also be a factor of heredity. If contrasted parental characters and changes of external conditions affect the vigor of organisms, why may not frequent changes of characters during the process of development be supposed to have a similar advantage? The specialization of two or more different kinds of leaves, branches, or flowers on the same plant may be compared with the alternative inheritance shown in the sexes and castes of animals, and both classes of specialization may have similar relations to the physiology of reproduction. Frequent conjugations between germ cells representing different lines of descent may be rendered less necessary in plants because of the numerous changes of characters that take place during the ordinary processes of growth.

CONCLUSIONS.

A definite dimorphism of the leaves exists in an Egyptian variety of the Deccan hemp (*Hibiscus cannabinus*). The leaves of the upper part of the stalk are deeply three lobed, while those of the lower part

are without lobes. The change from one form of leaves to the other is usually quite abrupt.

The various types of cotton and okra show the same general range of diversities of leaf forms as the Deccan hemp, and some of the varieties have the same tendency to dimorphic expression of the leaf characters. In other words, there is a general parallelism of variation in leaf characters extending through the many species and varieties of cotton, as well as the related genera of plants.

The definite changes of characters involved in passing from one form of leaves or branches to another are analogous to the abrupt transformations that take place in mutative variations. The facts of dimorphism and of bud variation indicate that mutative changes of characters are not necessarily connected with conjugation or with the early stages of sexual reproduction from new germ cells.

Dimorphic differences and mutations show that abrupt changes of characters are to be considered as phenomena of alternative expression. It is obvious that such changes are not determined by alternative transmission, as often alleged for Mendelian segregation of contrasted characters. The same kinds of characters show dimorphic specialization in individual plants and Mendelian segregation in hybrids. Dimorphism and Mendelism may both be interpreted as phenomena of alternative expression.

The general interest of such phenomena is in their relation to the recognition of a fundamental distinction between transmission and expression as a general law or principle of heredity. The facts of heredity and breeding can be better understood if transmission be considered as including the whole ancestral series of characters. Transmission inheritance is a comprehensive process, while expression inheritance is partial and alternative, different characters being expressed in different individuals or in different stages of individual development.

The facts of dimorphism are worthy of being taken into account in breeding, as affording additional varietal characters and as one of the means of recognizing variations from the standard or typical form of a select variety. Dimorphism must also receive attention in the study of the influence of environmental conditions on the expression of characters. In cotton and other tropical crop plants the modification of dimorphic differences represents one of the most serious disturbances of normal heredity induced by external conditions.

DESCRIPTION OF PLATES.

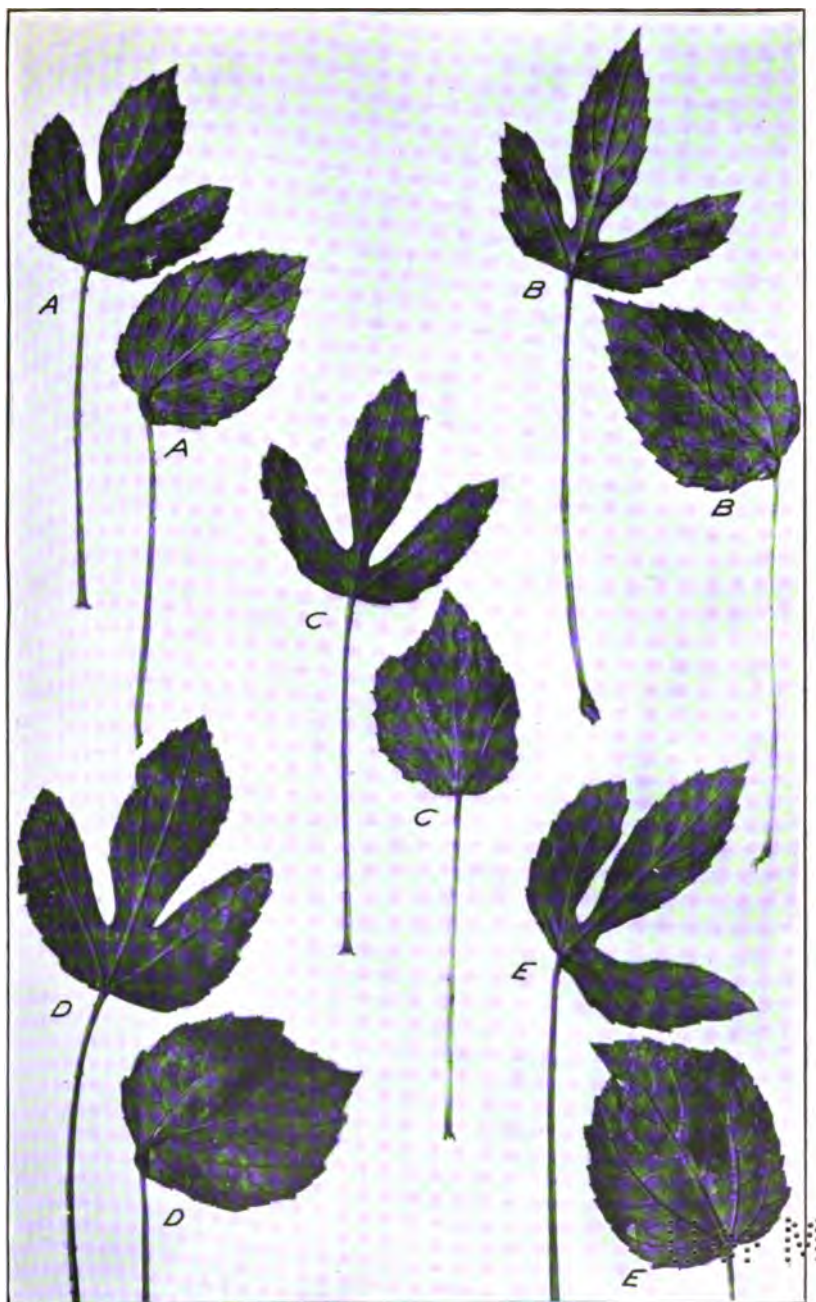
PLATE I. Dimorphic leaves from adjacent internodes of five plants (*A, B, C, D, E*) of *Hibiscus cannabinus*, two leaves from each plant, the highest of the simple leaves and the lowest of the divided leaves, showing the very abrupt change of form. (Natural size.)

PLATE II. Dimorphic leaves from adjacent internodes of four plants (*A, B, C, D*) of *Hibiscus cannabinus*, four leaves from plant *A* and three leaves from each of the others, showing the more gradual changes of characters. The plant leaves shown in this and the preceding plate were collected from plants grown on the borders of cotton fields at Gizeh, Egypt, July, 1910. (Natural size.)

PLATE III. End of fruiting branch of Egyptian cotton with normal leaves, stipules, and involucre bracts. Photograph from living plant grown at Sacaton, Ariz., in 1910. (Natural size.)

PLATE IV. End of fruiting branch of Egyptian cotton with abnormally enlarged stipules and reduced leaf blades, without lateral lobes. Photograph from living plant, Sacaton, Ariz., 1910. (Natural size.)

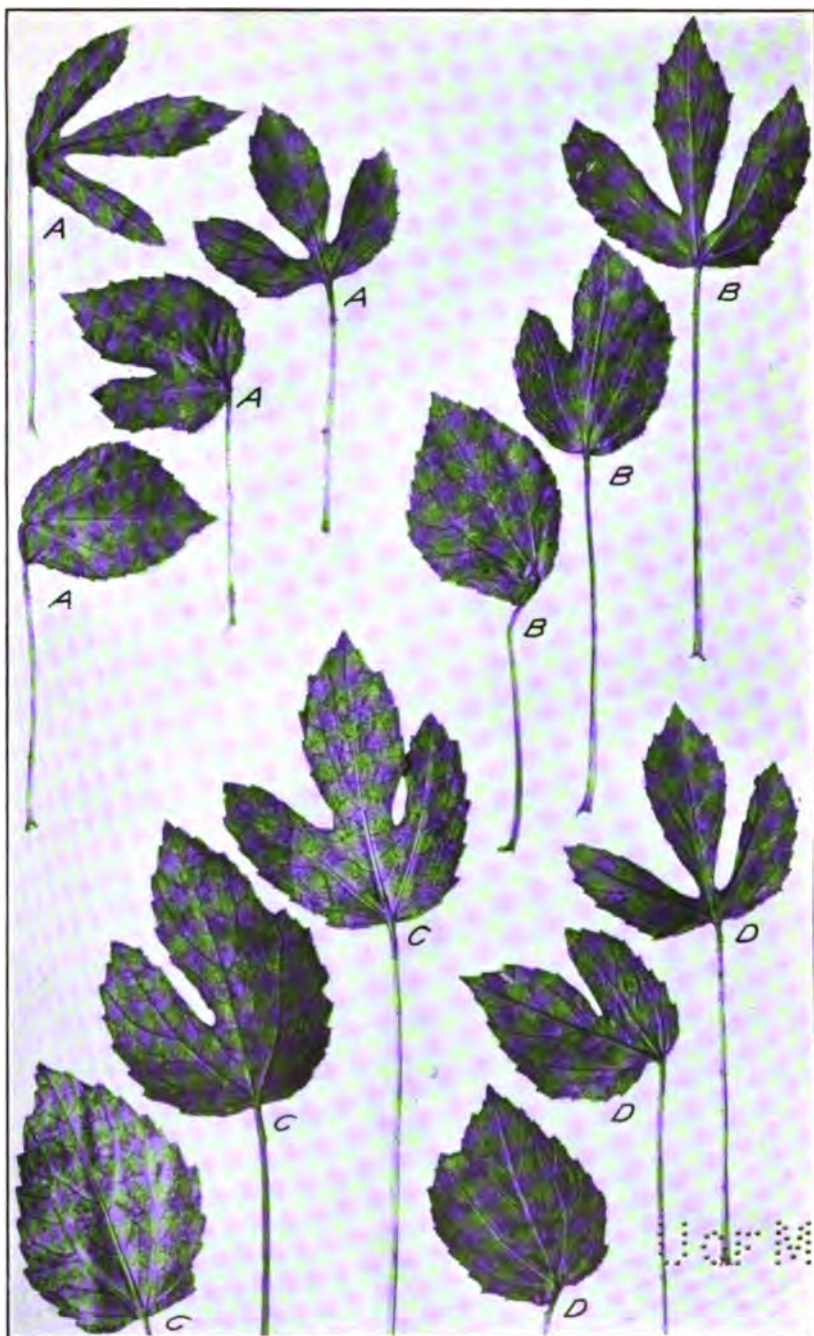
PLATE V. Hybridization of broad-leaved and narrow-leaved varieties of cotton: *A*, Leaf of Keenan variety; *B*, Ratteree's Favorite; *C*, hybrid. Photograph from dried specimens grown by Mr. H. A. Allard at Thompson's Mills, Ga. (Reduced.)



DIMORPHIC LEAVES FROM ADJACENT INTERNODES OF FIVE PLANTS (A, B, C, D, AND E) OF *HIBISCUS CANNABINUS*, SHOWING VERY ABRUPT CHANGES OF FORM.

(Natural size.)

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DIMORPHIC LEAVES FROM ADJACENT INTERNODES OF FOUR PLANTS (A, B, C, AND D) OF *HIBISCUS CANNABINUS*, SHOWING SOMEWHAT GRADUAL CHANGES OF FORM.

(Natural size.)

MRU



END OF FRUITING BRANCH OF EGYPTIAN COTTON WITH NORMAL LEAVES, STIPULES,
AND INVOLUCRAL BRACTS.

(Natural size.)

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END OF FRUITING BRANCH OF EGYPTIAN COTTON WITH ABNORMALLY ENLARGED STIPULES AND REDUCED LEAF BLADES, WITHOUT LATERAL LOBES.

(Natural size.)

1700



END OF FRUITING BRANCH OF EGYPTIAN COTTON WITH NORMAL LEAVES BIPINNATE
AND INVOLUCRAL BRACTS.
(Normal form)



LEAVES OF COTTON: (A) LEAF
NORMAL, AND (C) HYBRID.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 222.

B. T. GALLOWAY, *Chief of Bureau.*

ARRANGEMENT OF PARTS IN THE COTTON PLANT.

BY

O. F. COOK AND ROWLAND M. MEADE,
Crop Acclimatization and Adaptation Investigations.

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LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., May 10, 1911.

SIR: I have the honor to transmit herewith a paper entitled "Arrangement of Parts in the Cotton Plant," by Messrs. O. F. Cook, bionomist, and Rowland M. Meade, scientific assistant, of this bureau, and to recommend its publication as Bulletin No. 222 of the bureau series.

Notwithstanding the great agricultural importance of the cotton plant, its peculiarities have received very little study from the botanical standpoint. This bulletin describes the general structure and habits of the plant as affected by differences in the number, position, and arrangement of the various parts.

Respectfully,

WM. A. TAYLOR,
Acting Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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ARRANGEMENT OF PARTS IN THE COTTON PLANT.

INTRODUCTION.

The basis of all scientific study of cotton, as of other agricultural plants, is the recognition and comparison of differences. Whether experiments are being made for the breeding of better varieties or to determine the most favorable conditions or methods of culture, account must first be taken of the differences that are shown in the characters and behavior of the plants. The scientific interest and practical value of the results must depend very largely upon the ability of the experimenter to recognize such differences and to understand their relation to the development of varieties and to cultural problems.

Two principal kinds or classes of differences may be recognized in the study of such a plant as cotton. The component parts, such as the joints, leaves, flowers, or fruits, may differ, or there may be differences in the number and arrangement of parts that are otherwise alike. The body of the plant may be looked upon as a compound structure or colony built of several kinds of structural units, commonly called joints or internodes. Changes of behavior that are of serious economic importance may be brought about by changing the number and arrangement of the parts of the plants, even without altering the characteristics of the leaves, flowers, or other component units of structure.

Not only do the parts of an individual plant stand in relation to other parts of the same plant, but all the individuals of a pure strain or variety have the same system of arrangement of parts, though variously modified under different conditions of growth. The leaves and branches have definite positions on the stems, and the parts of the flowers and fruits have characteristic numbers and places, in addition to their peculiarities of form and color. Hybrids, mutations, and reversions usually show differences in arrangement of parts as well as in other characters. Differences in arrangement are often the most obvious and assist the breeder in recognizing the superior individuals and rejecting the inferior.

ARRANGEMENT OF THE LEAVES ON THE MAIN STALK OF THE COTTON PLANT.

The leaves of the cotton plant are not set at random along the stalks and branches, but are regularly arranged in ranks and spirals. In plants of normal growth it is usually easy to see that each leaf is directly above or below some other leaf and that there are three, five, or eight of these vertical ranks of widely separated leaves.

The regular spiral arrangement of the leaves is found on the main stalk and the vegetative branches. It is not apparent on the fruiting branches, for these have the joints twisted so that the leaves appear to stand in two rows.

The spiral arrangement of the leaves around a main stalk or a vegetative branch can be understood by considering the relation of any given leaf to the one next higher on the stalk. An imaginary line that would connect the insertions of the leaves would form a regular spiral, since it continues around the stalk in the same direction, to the right on some plants and to the left on others. On plants with three-ranked leaves the spiral makes one turn around the stalk in going from any given leaf to the next leaf that is directly above it. If the leaves are in five ranks the spiral makes two turns in going up to the next leaf on the same rank, while with eight-ranked leaves three turns are made.

Many individual plants will be found with their stalks so bent or twisted that no regular leaf arrangement is apparent, but in the majority of cases it is easy to ascertain which of the systems is followed. The regularity of the spiral is also destroyed if the growth of the stalk has been interrupted by dry weather or other injuries that cause the formation of very short joints. In such cases the direction of the spiral may even appear to be reversed.

Instances of such irregularities have been brought to our attention in cotton raised at Palestine, Tex., in the season of 1909, by Dr. D. N. Shoemaker, of the Bureau of Plant Industry. Some of the stalks had two or three sections of shortened joints and apparent reversals of the spirals. A possible explanation may be found in the fact that boll weevils, which were unusually abundant in the early part of the season, often eat out the terminal buds of the young plants. If the growth of the stalk were continued by an axillary bud it might be expected that the direction of the spiral would often be reversed, for the vegetative branches often differ from the main stalk in the direction of the spiral.

Botanists who have made special studies of the arrangement of leaves have found it convenient to describe the different systems by fractional numbers. The numerator of the fraction shows the number of turns that the spiral makes in passing from any given leaf to the next member of the same rank, while the denominator indicates the

whole number of vertical ranks of leaves. The fraction as a whole indicates the part of the circumference of the stalk included between two successive leaves of a spiral. The most frequent arrangement of the leaves of the cotton plant is in the three-eighths spiral. This means that the leaves stand in eight ranks, that three turns around the stem are made by the spiral in passing from any particular leaf to the next that is directly above it, and that successive leaves along the spiral are separated by three-eighths of the circumference of the stalk.

NEW WORLD COTTONS WITH THREE-EIGHTHS SPIRALS.

The arrangement of leaves in three-eighths spirals appears to be a normal characteristic of all pure strains of cotton belonging to the Upland and Sea Island species (*Gossypium hirsutum* and *G. barbadense*) and to the nearly related types that are natives of tropical America. This normal arrangement appears with much regularity in varieties introduced from tropical America, when planted for the first time in the United States. With the advance of acclimatization, the leaf arrangements are varied by frequent examples of one-third and two-fifths spirals, and similar irregularities are found among native Upland varieties. Pure stocks are much more likely to have the regular three-eighths arrangement than those not carefully bred.

Variations in the arrangement of the leaves were first noticed in Egyptian-Upland hybrids, but were found later in all hybrid stocks, including many crosses between different Upland types. Hybrid plants may have a one-third, two-fifths, or even a five-thirteenths spiral arrangement, although both parents may have had the normal three-eighths arrangement, or hybrids may have the normal arrangement of the parents. The very general prevalence of the three-eighths spiral among American types of cotton warrants the suspicion that any plant without the normal three-eighths arrangement is of hybrid origin or the result of recent mutative variation.

On the other hand, there is a possibility that the regularity of the three-eighths arrangement in the newly imported stocks may represent one of the tendencies of reversion that are very frequently shown in other characters of the plants. The simpler forms of spirals may be correlated with the smaller size and more fertile habits of growth of acclimatized stocks, but if this be true some varieties should be found with the simpler spirals as a regular feature. The systems of arrangement followed by the foreign cottons in their native countries must also be ascertained before definite conclusions can be drawn regarding the effects of new conditions and acclimatization.

Mutative stocks, as far as known, differ from hybrid stocks in that all the plants of a stock have the same leaf arrangement. This may be like the stock from which the type mutated or it may be different. The only type of Upland cotton that seems to show a regular deviation

from the three-eighths system of arrangement is a peculiar variety with deeply divided leaves called "Park's Own," which is said to have originated as a mutation from the King cotton. Small plantings of this variety have shown the two-fifths arrangement with apparent regularity. Three plants raised at Kerrville, Tex., in 1908 from the seed of a Triumph mutation had a one-third arrangement. The leaf arrangement of the parent plants was not noted, but the Triumph variety has the usual three-eighths spiral.

OLD WORLD COTTONS WITH ONE-THIRD SPIRALS.

In contrast with the three-eighths system of leaf arrangement of the Central American varieties, all the newly introduced Asiatic cottons show a one-third system of leaf arrangement. Among the hundreds of plants that have been grown from imported seed, including representatives of several Old World types that are reckoned as distinct species (*Gossypium herbaceum*, *G. arboreum*, *G. indicum*, *G. neglectum*, etc.), only one exception to this rule has been noted. A single plant of a variety from Bokhara, grown at New Braunfels, Tex., in 1909, appeared to have a two-fifths arrangement of the leaves along the vegetative branches. This plant had been injured when young, so that the main axis had not developed.

Later generations of the Asiatic species from seed raised under conditions that would permit crossing with other Asiatic species have produced plants with two-fifths and three-eighths arrangements. Some of these plants with the more complex spirals were obviously hybrids, and others may have been. Although hybridization does not appear to take place between Old World cottons and New World types, crossing between different Old World cottons seems to have the same effect of inducing variations of leaf arrangement as among the Upland types of cotton, and the leaf arrangement also seems to change with the progress of acclimatization. There is a contrast, however, in the fact that in the New World hybrids or acclimatized plants the spirals tend to become more simple, while in the Old World cottons they become more complex.

ARRANGEMENT OF THE BRANCHES ON THE MAIN STALK.

At the base of each leaf of a cotton plant two buds are to be found. The true axillary bud stands just above the middle of the base of the leaf. The lateral or extra-axillary bud stands at the right or the left of the axillary bud, depending on the direction of the spiral in which the leaves are arranged.

The two buds differ in their power of forming branches. Only "limbs" are produced from axillary buds. All the branches that bear flowers and fruit before again branching come from lateral or extra-axillary buds. Near the base of the plant lateral buds may

also develop into vegetative branches instead of fruiting branches, but no normal fruiting branches have been found to grow from axillary buds.

The axillary buds usually develop into branches on only a few joints in the lower part of the main stalk. They usually remain dormant on the joints that produce fruiting branches. It often happens, however, that two buds develop at the same joint, one into a vegetative branch and the other into a fruiting branch. (Fig. 1.) In some varieties of cotton this double-branched condition of some of the lower joints of the stalk is a regular feature.

As already indicated, the differences of origin and position enable two kinds of vegetative branches to be distinguished, the true axillary limbs and the vegetative branches that rise from extra-axillary buds. Though both kinds of vegetative branches have the same appearance and function, it is desirable to recognize the difference of arrangement because the extra-axillary vegetative branches often replace the fruiting branches, to the serious detriment of the crop. Two vegetative branches, one of each kind, may appear at the same node, but this is a rather rare occurrence.



FIG. 1.—Stalk of Lone Star Upland cotton, with (A) vegetative and (B) fruiting branches from the same nodes. (Natural size.)

Though the limbs are always represented by buds in the axils of the leaves, the various types and varieties of cotton differ greatly in their tendencies to develop them as regular parts of the plant. In

some varieties the axillary branches are represented only by small rudiments or mere dormant buds, or they may die and drop off, leaving only minute scars, often difficult to detect in mature plants. When the limbs are produced they usually take a more upright position than the fruiting branches and often attain a height as great or greater than that of the main axis of the plant. In plants that have been injured or pruned or that have had their growth interrupted by dry weather, limbs may develop late in the season, either from basal joints of the stem or from joints that have already produced fruiting branches. At the base of the plant the vegetative branches usually grow more rapidly than the limbs, so that the latter may be forced to one side or their development arrested, but near the middle of the plant a limb and a fruiting branch may occur at the same node and may develop to about the same extent. In the Upland types of cotton the vegetative branches seldom occur above the fifth node from the base of the plant. The Egyptian cotton has a much stronger tendency to produce vegetative branches.¹

Vegetative branches often grow as tall or taller than the main stalk and are generally larger than the limbs when both are produced on the same plant. They usually develop only at the base of the plant, but are often quite numerous and may even replace the fruiting branches over the whole plant, as often occurs in the first generation of foreign cottons introduced into the United States. Plants that develop only vegetative branches are rendered completely sterile. Having no fruiting branches they are unable to form any flower buds. This condition of sterility is to be distinguished from another that is still more common in unacclimatized stocks. Although fruiting branches are present the flower buds may all be abortive in the early stages, so that no flowers are produced. Moreover, plants that are able to produce an abundance of flowers may still fail to set any bolls.

Hybrids may also be rendered sterile in the same ways. An important step in the improvement of all cottons by selection is the removal of all plants showing a tendency to multiply vegetative branches at the expense of fruiting branches. Even though large branching plants may produce large quantities of cotton, seed from such plants should not be selected; furthermore, the crop ripens late and the yield per acre is generally less than can be secured from small plants. The presence of the boll weevil greatly increases the disadvantage of growing late varieties.

A special study of the branching habit of Egyptian cotton in Arizona has been made by Mr. Argyle McLachlan, of the Bureau of Plant

¹See "A Study of Diversity in Egyptian Cotton," Bulletin 153, Bureau of Plant Industry. Also "Dimorphic Branches in Tropical Crop Plants: Cotton, Coffee, Cacao, the Central American Rubber Tree, and the Banana," Bulletin 198, Bureau of Plant Industry.

Industry, who finds that the vegetative branches are produced for 12 to 14 nodes from the base of the main stalk in plantings of newly imported seed, whereas in acclimatized strains the number of vegetative branches is distinctly reduced and the production of fruiting branches usually begins five or six joints closer to the ground.

Weather that is dry enough to retard the growth of the plants also discourages the formation of limbs and vegetative branches, while humid conditions favor the production of both. After a prolonged drought at San Antonio, Tex., during the season of 1909, no plants of either New World or Old World cottons could be found with limbs, except as short rudiments, though many of the basal extra-axillary vegetative branches were well developed. The dry weather was apparently able to suppress the limbs without seriously restricting the growth of the extra-axillary vegetative branches that had begun to develop early in the season.

With an abundant supply of water the limbs may be forced into vigorous growth and may gain a predominance over the vegetative branches, as was well illustrated at Del Rio, Tex., during the same season. There the cotton from the same stocks as those in the San Antonio experiment received a plentiful supply of water, and limbs were much more numerous than vegetative branches. The vegetative branches usually outnumber the limbs unless the latter have been forced into growth late in the season.

ARRANGEMENT OF THE LEAVES ON THE LIMBS AND VEGETATIVE BRANCHES.

The arrangement of the leaves and buds on both the axillary limbs and the vegetative branches is the same as on the main stalk of the cotton plant. If the main stalk has the normal three-eighths arrangement all the limbs and vegetative branches follow the same system, no matter how many branches the plant may have. Deviations from the normal spiral on the main stalk are also accompanied by abnormal arrangements on the vegetative branches.

There seems to be little or no regularity in the directions of the leaf spirals on either the vegetative branches or the limbs. Often several succeeding vegetative branches will turn their spirals in the same (right or left) direction, while again they seem to alternate their direction with some regularity. The direction of the spirals of the vegetative branches often appears to agree with that of the main stalk in cases where the vegetative branches are few in number, but if the branches are numerous, differences in the direction of the spirals can usually be found. If a limb and a vegetative branch develop at the same node, their spirals may follow the same direction or may be opposed.

ARRANGEMENT OF THE FRUITING BRANCHES.

The fruiting branches of the cotton plant are developed from the extra-axillary buds that stand slightly above and at one side of the axillary buds of the main stalk and the vegetative branches. Fruit-

ing branches are very seldom produced from the lowest nodes of the main stalk or the vegetative branches. Even when no limbs or vegetative branches are developed at the base of the plant, the fruiting branches usually do not appear below the fourth or fifth joint of the stalk. When vegetative branches are present there is often an interval between them and the fruiting branches, a condition found by Mr. McLachlan to be especially prominent in the Egyptian cotton in Arizona.

The node at which the fruiting branches are first produced on the plant varies considerably, not only in the different varieties and types, but also in different conditions of growth. In Egyptian cottons this zone is from the eighth to the fourteenth nodes, while in the Upland cottons it is from the fourth to the fifth. In Upland cotton fruiting branches may begin to be formed very low down, only one or two nodes above the cotyledons, while in Egyptian cottons they generally begin much higher up, between the tenth and the fourteenth nodes. When the vegetative growth is very luxuriant the fruiting branches may be still higher up, or they may fail altogether, all being replaced by branches of the vegetative sort, as already noted.

Fruiting branches have a nearly horizontal instead of a vertical or ascending position. The basal joints are also longer than those of the vegetative branches, and the other joints are usually shorter, twisted, and more or less zigzag. (Fig. 2.)



FIG. 2.—Two Internodes of a fruiting branch of Upland cotton. (Natural size.)

ARRANGEMENT OF THE LEAVES AND FLOWERS ON THE FRUITING BRANCHES.

As previously stated, the leaves of the fruiting branches do not show the definite leaf arrangement of those on the main stalk and vegetative branches. The twisting of the joints of the fruiting

branches brings the flower buds into an upright position and allows the leaves to stand out in two alternate rows along the sides of these branches. If one joint of the fruiting branch is twisted to the right, the next is twisted to the left, and so on in regular alternation, bringing every second leaf nearly in line with the one two nodes distant.

The direction of the twist of the basal joint also appears to have a regular relation to the position of the branch on the main stalk. Branches that come out at the right of the leaf axil usually have the basal joint twisted to the right; others to the left. The twisting brings the first leaf of the fruiting branch opposite the leaf on the main stalk, at the base of the branch. This alternation suggests the possibility that the fruiting branch may represent a specialized branch from the base of the axillary limbs.

The leaves of the fruiting branches, unlike those of the main stalk and vegetative branches, are often irregular in outline. If there is an odd number of lobes those on the side of the blade away from the branch are usually much larger than those alongside of the branch. These leaves often have two nectaries, or only one, instead of the three nectaries common to the leaves of the main stalk, one borne on the midvein and the second on the primary vein subtending the large lobe on the side of the blade away from the branch.

The flower buds do not come out from the axils of the leaves, but often appear to be separated by almost half the diameter of the stem. In cluster cottons, or others that have abnormal branches, the pedicel, or stem of the flower, appears as a continuation of the joint of the fruiting branch and lacks the usual absciss-layer that allows the blasted buds to fall off or the bolls to separate at maturity. This may indicate that the fruiting branches have what botanists describe as the sympodial method of growth, as though each joint were terminated by the flower and the next joint formed by the development of a new lateral bud.

In addition to the bud that continues the growth, there are buds in the axils of the leaves of the fruiting branches, and if these develop they may produce vegetative branches of the usual form. In other cases the axillary buds of the fruiting branch may produce very short vegetative branches, and these may give rise in turn to very short fruiting branches, so that one joint of a fruiting branch may appear to bear two or three bolls in an exceptionally fertile plant. Careful examination will show that only one boll is borne directly on the joint and that the others come from branches of the short axillary.

In the Asiatic species the flowers are often pendent and are borne somewhat on the sides of the branch, more nearly opposite the leaves. The leaves are arranged the same as those of the Upland and nearly related types of cotton.

ARRANGEMENT OF THE INVOLUCRAL BRACTS AND BRACTLETS.

Each flower bud of the cotton plant is protected by an involucre composed of three specially reduced and modified leaf-like organs, technically called bracts. Inside the involucre, between the bracts and the bud proper, still smaller leaf-like organs, the so-called bractlets, may occur. Both the bracts and the bractlets give indications of regular arrangement.

Two of the bracts are of equal size and are often appreciably larger than the third. The small bract is always borne on the side of the flower that faces outward, toward the end of the branch. (Fig. 3.) Bractlets are most likely to be associated with this small bract. If only two bractlets are present, as frequently happens, they stand at

either side of this small outer bract. In the Kekchi cotton and other Central American types the bractlets often occur in pairs, alternating with the bracts, though it is rather unusual to find a complete set of six bractlets.

When a fourth involucre bract occurs, it develops at one side of

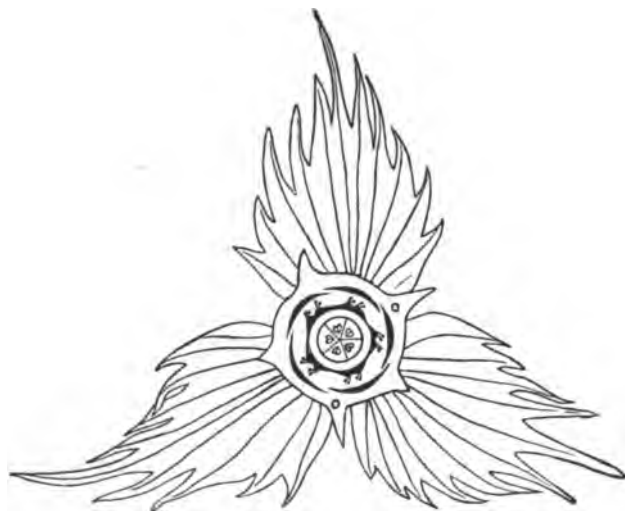


FIG. 3.—Diagram showing the relation of parts in the cotton flower. (Bracts and calyx teeth natural size.)

the smaller bract, the side that is toward the leaf of the same node. This additional fourth bract has always been found to be smaller than the third and is even more likely to be accompanied by bractlets.

The laciniae, or teeth, of the younger bracts are often bent or twisted in one direction and overlap those of another bract, completely inclosing the young bud. (Fig. 4.) At one node the laciniae twist in one direction and at the next the direction is reversed. This twisting is opposite in direction to that of the internode which bears the flower and in the same direction in which the petals of the same flower overlap.

ARRANGEMENT OF THE LOBES OF THE CALYX.

The calyx of the cotton flower is usually very small, the usual function of the calyx, to protect the young bud, having been assumed by the much larger involucre bracts. The calyx forms in most kinds of

cotton merely a shallow cup around the bases of the petals. The margin of the cup is more or less divided or produced into five lobes, sometimes short and broad, sometimes long and pointed. The assumption that these lobes represent as many sepals or bracts of some ancestral relative is warranted by their position and by the fact that a transparent line is also sometimes to be seen, extending from the sinus between two lobes to the base of the calyx.

Seldom, if ever, is a calyx found with lobes of uniform size. Usually there are two large lobes, two small lobes, and one of intermediate size. In the Egyptian cotton and in some of the Asiatic species, calyxes are found with the margin almost evenly truncate, but it is usually possible to distinguish the five lobes and to see that they are of unequal size.

One of the small lobes stands between the two large lobes and is always on the outer face of the calyx, that is, opposite to the small outer bract of the involucre. (Fig. 5.) The other small lobe is between one of the large lobes and the intermediate lobe, but it may be on either side of the intermediate lobe. The position of the second of the small lobes with reference to the intermediate lobe has a constant relation to the twisting of the other parts of the flower. If the petals twist to the right the intermediate lobe is at the right of the small lobe, and vice versa. These relations can usually be ascertained without much difficulty, though abnormal calyxes are occasionally found, especially in connection with irregularities in the petals and other floral organs.

In view of the fact that organs of intermediate form are often found, it is not unreasonable to consider the so-called calyx as belonging to the same series of modified leaf organs as the outer involucral bracts. In other words, the so-called calyx may be looked upon as the inner involucre rather than as a true calyx. This view seems to give a better understanding of the arrangement of parts. It would explain, for example, the further fact that the smallest lobe, on the outer (distal) side of the calyx, seems to stand directly opposite to the small outer bract of the involucre, whereas none of the other lobes appears opposite to the bracts. The small outer involucral bract would commence and the smallest lobe of the calyx would complete one whorl or series of eight leaves in the usual system of leaf arrangement.



FIG. 4.—Bracts of Upland cotton inclosing bud, showing twisted teeth. (Natural size.)

The two large lobes of the calyx alternate with two of the involucre bracts, and each of these lobes is usually provided with a nectary. The intermediate lobe and the remaining small lobe do not appear to be definitely alternate or opposite to any of the bracts. (Fig. 6.) Often the intermediate lobe approaches the size of the large lobes, especially in the Upland varieties. It then appears more nearly alternate with the involucre bracts and usually has a nectary at its base, like the other large lobes. In other cases the nectary is usually absent.



FIG. 5.—Flower of Upland cotton, from the side, showing the position of the small calyx lobe opposite the smallest bract. (Natural size.)

ARRANGEMENT OF THE INTRACALICARY ORGANS.

Inside of the calyx of the cotton flower, between the calyx and the petals, a series of small, greenish, oboval or spatulate organs may often be found. (Fig. 7.) The complete number of these organs is five and they are arranged in regular alternation with the lobes of the calyx. The size is extremely variable, so that the full number is seldom to be seen by the naked eye. Some of them are usually represented by minute rudiments visible under a lens as small tufts of hairs at the base of the calyx. When very large they may extend to the

margin of the calyx, and in rare cases may project slightly above it.

That these organs are arranged in alternation with the lobes of the calyx is rendered the more apparent by the fact that they stand in front of faint transparent lines that mark the sutures between the component parts of the calyx. This was first observed in the Willet's Red Leaf variety of Upland cotton, where the deep-red color of the outside of the calyx makes the transparent lines more distinct. These lines are often very faint, but they seem to be generally present.

The intracallicary organs may be free from the calyx to near the base or they may be united with the calyx at the back, along the sutures

which separate the calyx lobes. They are somewhat thickened and fleshy at the base, but become very thin toward the apex. Like other parts of the calyx they are well spotted with oil glands and have faint veinlets radiating from a transparent median line.

The fact that these organs are frequently adherent to the calyx lobes and that they often have a transparent median line, somewhat like the sutures that separate the lobes, suggests that they may represent ingrown margins of the calyx lobes. Or they may be considered as stipular elements of the calyx lobes, brought into expression in an irregular manner, like the bractlets that appear on the outside of the calyx. If viewed as independent organs, apart from the calyx, it is necessary to suppose that they represent rudimentary internodes or joints of the floral branch, intercalated between the calyx and the corolla, perhaps analogous to the suppressed or rudimentary branches that occur from the interval between the vegetative branches and the fruiting branches.

If reckoned as parts of the calyx, the intracallicary organs add to the morphological



FIG. 6.—Flower of Upland cotton, from below, with bracts removed, showing the arrangement of calyx lobes, petals, and nectaries. (Natural size.)

analogies between the calyx and the involucre. If supposed to represent independent metamers, the intermediate position of the intracallicary organs would indicate that the so-called calyx is really a part of the involucre, since it is separated from the corolla by the intracallicary organs, which might even be considered as rudiments of the true calyx. It is possible that a study of the irregularities in the formation of the involucre in relation to different systems of phyllotaxy would give more definite indications regarding some of the morphological questions. The three bracts and the five calyx lobes would represent one complete whorl in a three-eighths system, but not in a two-fifths or a one-third system.

ARRANGEMENT OF THE PETALS.

The five petals of the cotton flower stand in alternation with the five lobes of the calyx and are inserted on the base of the staminal column, one petal at the base of each of the five lobes or ridges of the column. Abnormal flowers sometimes occur with six or more petals or with small petal-like organs on the base of the staminal column, above the large petals—another indication of the relation of the petals to the staminal column.

The arrangement of the five petals of the cotton flower in the bud may be described as convolute; that is, each petal overlaps the next. Sometimes the petals overlap to the right, sometimes to the left. If the internode that bears the flower twists to the right, the petals of the flower overlap to the left, and vice versa.

Looking into the flower, it appears that the petals and the stamens twist in the same direction. The direction of the twisting of the petals is reversed in each succeeding flower, as is the case with the internode of the fruiting branch which bears the flower. Finally, the petals twist in the same direction as the teeth of the bracts and stamens of the same flower. (Fig. 8.)



FIG. 7.—Calyxes of Cochin China Upland cotton, showing intracallicary organs alternate with calyx lobes. (Slightly enlarged.)

ARRANGEMENT OF THE STAMENS.

The cotton flower has a large cluster of stamens, often as many as 90, all inserted on a tubular sheath of tissue known as the staminal column. This surrounds and covers the pistil, allowing only the stigmas and part of the style to project beyond the cluster of stamens. If the style is long, as in the Egyptian cotton, the stigma may be carried well above the stamens, so that insects may be required for fertilization. In the Upland cottons the style is generally shorter and the stigmas may remain buried among the stamens, insuring self-fertilization.

Though the stamens may at first appear to have no regularity of arrangement, it is usually possible to see that they spring from five vertical ridges of the staminal column, often ending in as many teeth

or lobes. The position of these ridges is opposite to that of the petals. Often there appear to be two rows of stamens on each ridge, one on either side. All of the filaments are usually bent in the direction of the twist of the petals and stigmas of the same flower.

The staminal column is reckoned by botanists as one of the peculiar characteristics of the mallow family, to which the cotton belongs. Some of the relatives of the cotton have only 5 or 10 stamens and little or no development of the staminal column. Abnormal cotton flowers are sometimes found with the column very short or split to the base into five separate lobes that may represent as many original stamens. On some plants all gradations may be found between this form of separate short lobes bearing few stamens, sometimes only two, and the elongated column of ridges bearing an indefinite number of stamens.

In other words, the staminal column may be looked upon as composed of the united filaments or bases of the many stamens that are separated only at the end. The presence of partly divided anthers and of



FIG. 8.—Flower of Upland cotton, from above, showing the position of petals, stigmas, and stamens. (Natural size.)

branched filaments, bearing two, three, or four anthers, also suggests the possibility that the large number of stamens now present in a normal cotton flower may have been attained by the subdivision or branching of an originally small ring of stamens. This would explain why the staminal tube has been developed as a common base for all the stamens instead of having them separately inserted, as in most of the families of plants that have numerous stamens.

ARRANGEMENT OF THE CARPELS.

The number of stigmas of the cotton flower is the same as that of the carpels, or "locks," of the ripe seed pod or "boll." In contrast

with the generally constant number of bracts, calyx lobes, and petals, the number of carpels is always varied, even among the flowers of the same plant. No variety of cotton is known to have a constant number of carpels. In Upland cotton four-locked and five-locked bolls are the rule; in Egyptian and Sea Island varieties the bolls are three locked and four locked. Three-locked bolls are occasionally found in Upland cotton, and two-locked bolls in Egyptian. Six-locked bolls are of rare occurrence. Abnormal bolls with still larger numbers of locks result from fasciation, especially in the "cluster" varieties of Upland cotton.

When the number of carpels is less than five it does not appear that they have any regularity of arrangement with reference to other parts of the flower, but when five carpels are present they appear to stand in alternation with the lobes of the staminal column and the petals and opposite the calyx lobes. The stigmas are not usually twisted, but sometimes they are bent in the direction taken by the stamens and petals.

ARRANGEMENT OF THE HAIRS ON THE SURFACE OF THE SEED COAT.

Although not to be considered in detail in the present paper, the distribution of the hairs on the surface of the cotton seed is another subject worthy of study from the standpoint of position and arrangement. In most of the different species and varieties of cotton the seed produces two distinct kinds of hairs. The long hairs represent the commercial fiber, or lint, and the shorter, finer hairs represent the fuzz left on the seed after ginning. The fuzz may be white like the lint, but is often green or brown. If no fuzz is produced the seeds are left black and naked after ginning. Naked-seeded variations are quite common in some varieties of Upland cotton and are very undesirable because the absence of fuzz is nearly always accompanied by a serious reduction in the amount of lint. In a few cases plants have been found with neither fuzz nor lint. Though the presence of fuzz seems to be correlated with abundance of lint, very fuzzy seeds sometimes have very few of the long lint fibers; sometimes none at all.

In the Upland type of cotton the two kinds of hairs are mixed together over the whole surface of the seed, but in other sorts there are definite differences in the position of the lint and fuzz. In the Egyptian cottons there is a strong tendency to restrict the fuzz to the ends of the seed and the lint to the intermediate position. A peculiar form of Sea Island cotton found in a locality called San

Lucas, in eastern Guatemala, between Cajabon and Senahu, shows the most extreme specialization of the two kinds of hairs on the seed. The lower half of the seed is without lint, but has a dense, velvety covering of bright-green fuzz. The upper half of the seed produces lint but no fuzz.

In addition to the positional relation of the fuzz and lint there are also differences in the lengths of the lint fibers on different parts of the seed. Some varieties of Upland cotton have a strong tendency to have the fibers of the upper part of the seed distinctly longer than those of the lower part, so that when the lint is parted and combed out from the seed a "butterfly" outline is formed. The butterfly tendency is undesirable because inequality in the lengths of the fibers lessens the commercial value of the cotton for spinning purposes. Even when the long fibers are not all restricted to the upper part of the seed, the lower part may show an evident preponderance of shorter fibers.

ARRANGEMENT OF THE ROOTS AND UNDERGROUND SHOOTS.

The central stalk of the cotton plant extends into the ground to form the taproot. The lateral roots arise in four rows from four shallow vertical grooves, one on each side of the taproot. The regularity of arrangement is often obscured by the bending and twisting of the taproot, as well as by the fact that the lateral roots take different directions and develop very unequally. But most plants show definite indications of an arrangement of the roots in rows, and in occasional individuals, where all the roots happen to project at right angles, the four-ranked character of the root system is very plain, even in old plants. (Fig. 9.)

In addition to the various kinds of buds and branches already described, the cotton plant is able to produce underground shoots from the same grooves as the roots. The underground shoots have at first a rounded or irregular form, like root nodules or galls, and may represent modified root primordia. The nodules grow to various sizes, sometimes attaining a diameter of nearly an inch before showing the leafy bud that develops into a vegetative branch. The similarity to crown galls may prove interesting and even worthy of study from the standpoint of pathological tissues.

Subterranean shoots seem to be developed much more freely in the Egyptian cotton than in Upland varieties. They seemed to be generally distributed over a whole field of several acres of Egyptian cotton at Bard, Cal., where nearly all of the plants were killed down to the ground in the winter of 1910-11. The roots of all the plants

that were dug up in different parts of the field were found to be alive and showed in May, 1911, many different stages of development of the subterranean shoots. Several of the lower leaves of such branches were small and distorted, but normal leaves were produced on shoots that had emerged from the ground.



FIG. 9.—Taproot of Egyptian cotton, showing the arrangement of lateral roots and underground shoots.

In cases where the plants had not been killed too far down, new shoots had been formed at the axils of the cotyledons and no subterranean shoots or nodules were found. If the buds in the axils of the cotyledons had developed into limbs in the previous year, new adventitious buds were produced from the swollen bases of the limbs. The branches from such buds were very small and slender at first, quite unlike the large, fleshy excrescences that gave rise to the underground shoots. The lower part of the stalk, representing the hypocotyl of the seedling, between the cotyledons and the surface of the ground, seems to have no power of producing adventitious buds. Nor did any of the nodules appear upon the lateral roots of any of the plants that were dug up. They seem to be entirely confined to the same lines or grooves which give rise to the normal lateral roots, and often show very clearly the same arrangement in four vertical rows. (Fig. 9.)

CONCLUSIONS.

Plants are compound organisms built up by many units of structure, the internodes or metamers. In studying the anatomy of a plant like cotton, two principal classes of differences may be taken

into account: (1) Differences in the characteristics of the component parts of the plant and (2) differences in the number or the arrangement of the component parts.

The leaves and branches of the cotton plant have a regular arrangement in spirals. The normal arrangement in the Upland, Sea Island, and Egyptian varieties of cotton and nearly related types is in three-eighths spirals. Old World cottons, on the other hand, have the leaves and branches in a one-third spiral,

Hybridization produces deviations from the normal number of spirals of the parent stocks. Among the Old World types of cotton, hybrids show a tendency to produce plants with the more complicated arrangement of leaves, while among the Upland hybrids the tendency is to arrangements simpler than normal. Mutative variations may agree in leaf arrangement with the parent stock or may show different arrangements.

The cotton plant has two kinds of branches, differing in arrangement as well as in other characters. Fruiting branches develop laterally from extra-axillary buds at the side of the axillary buds, which produce the limbs. Extra-axillary buds may develop into vegetative branches and replace fruiting branches, but no normal fruiting branches are produced by axillary buds.

The leaves of the limbs and vegetative branches of the cotton plant have the same spiral arrangement as those of the main stem, though the direction of the spiral on the limbs and vegetative branches may be opposed to that on the main stalk. Each internode of the fruiting branch is twisted in the opposite direction from the one preceding, bringing the leaves in two alternating series along the sides of the branch and the flowers into an upright position.

The involucre of the cotton flower is composed of three bracts, two of equal size and one smaller. The small bract is always on the outer or distal side of the flower, toward the end of the branch. Two bractlets frequently appear on either side of the small bract in United States Upland varieties, while in certain Central American types a complete series of six is sometimes developed, one on either side of the three bracts. The teeth of the bracts when twisted follow the same direction as the overlapping of the petals

The calyx of the cotton flower has five lobes distinctly unequal in size, two large, two small, and one intermediate. One of the small lobes stands opposite the small bract of the involucre, between two large lobes. The arrangement of the other lobes varies in relation to that of other parts of the flower.

Small flaplike organs are often inserted between the calyx and the petals, arranged in alternation with the calyx lobes. These intracalicular organs may be considered as supernumerary calyx lobes or as

representing free stipular elements of the calyx lobes. In either case they support the view that the calyx lobes are homologous with the bracts of the outer involucre. In other words, the calyx of the cotton plant may be looked upon as an inner involucre.

The petals of the cotton flower are opposite the lobes of the staminal column and overlap in the same direction as the stamens are bent. This direction conforms to the twisting of the internode of the branch bearing the flower and is reversed in the flowers at each succeeding node.

The stamens are arranged on the staminal column in five vertical rows, about the pistil, opposite the petals, and turn in the same direction as the overlapping of the petals. The paired positions and frequent branching of the stamens suggest the development of the compound staminal column by the subdivision of a few primitive stamens.

There is a persistent irregularity in the number of carpels, in the flowers and fruits of the same plant. The range of normal variation is from two to four carpels in the Egyptian cotton and from three to five carpels in the Upland cotton. When the number is five, the stigmas and carpels alternate with the petals and the lobes of the staminal column.



U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 223.

B. T. GALLOWAY, *Chief of Bureau.*

SEEDS AND PLANTS IMPORTED

DURING THE PERIOD FROM JULY 1
TO SEPTEMBER 30, 1910:

INVENTORY No. 24; Nos. 28325 to 28880.

ISSUED NOVEMBER 27, 1911.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

BUREAU OF PLANT INDUSTRY.

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LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., June 6, 1911.

SIR: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 223 of the series of this Bureau the accompanying manuscript, entitled "Seeds and Plants Imported during the Period from July 1 to September 30, 1910: Inventory No. 24; Nos. 28325 to 28880."

This manuscript has been submitted by the Agricultural Explorer in Charge of Foreign Seed and Plant Introduction with a view to publication.

Respectfully,

WM. A. TAYLOR,
Acting Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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SEEDS AND PLANTS IMPORTED DURING THE PERIOD FROM JULY 1 TO SEPTEMBER 30, 1910: INVENTORY NO. 24; NOS. 28325 TO 28880.

INTRODUCTORY STATEMENT.

No satisfactory test can be made of a new plant to determine its economic value until many months, or even years, have passed since its introduction. To emphasize those included in this inventory before they are tested may therefore appear somewhat premature, but it seems warranted for the reason that while in the printed descriptions new plants which arrive may seem much alike and equally interesting, to those who see all the correspondence which has led up to their introduction some of the new arrivals stand out as of special promise.

Those interested in the cover-crop problem of the California orange growers will notice the importation of a half ton of seed of the Palestine kirsenneh (*Vicia ervilia*, No. 28761) and 500 pounds of seed of another Palestine legume (*Lathyrus sativus*, No. 28762), and will note also the opinion expressed by Mr. Aaron Aaronsohn that the *Lathyrus* will make a quicker growth in the California orange orchards than *Vicia ervilia* and will have an advantage over the fenugreek that is now used there in that seed can be obtained cheaper.

The unusual interest in the mango in Florida, Porto Rico, and Hawaii has made it desirable to get the best East Indian varieties as rapidly as possible to increase the collection, which now numbers more than a hundred sorts. Some of these are early and others late ripening sorts; others have unusual keeping qualities; while still others are in the form of seeds imported for the purpose of originating new varieties. As pointed out by Mr. Walter T. Swingle in his citrus work, seeds like the mango, which are polyembryonic, are likely to give rise through the unfertilized embryos to strains of the original variety, which are characterized by increased vigor and productiveness.

So much interest has been aroused in the possibilities of the oriental persimmon through the introduction of the Tamopan variety and the perfection by Mr. H. C. Gore, of the Bureau of Chemistry, of new methods by which the tannin can be rendered insoluble in a practical way and the fruit hold its firm texture that a special search is being

made for all the species of *Diospyros* which may in any way be of value for breeding purposes or as a stock. Special interest may attach to *Diospyros peregrina* (No. 28584), from Sibpur, Calcutta, from the fact that the expressed juice when boiled with powdered charcoal is used on a large scale for paying the bottoms of boats and that an excellent glue is made from the juice by the natives of the Malabar coast. *Diospyros montana cordifolia* (No. 28684), a tree which is found from the Himalayas to Australia and which bears small fruits the size of cherries, and *Diospyros microcarpa* from Australia (No. 28343) have also been secured.

Two strains of maize from the Kalahari Desert region of South Africa (Nos. 28614 and 28615) and a form from Zomba, Nyasaland Protectorate (No. 28661), may interest the corn breeders.

Dr. A. Weberbauer, whose collections in the Peruvian Andes are well known, has sent two wild forms of *Solanum* from the region about Lima. One, which he believes to be *Solanum maglia*, is from the cool, cloudy Loma region and the other from the same vegetation zone is an undetermined form (Nos. 28656 and 28657).

Western China is known to have many wild species of *Rubus*, some of which are reported to bear fruit of unusual excellence. The vigor of the Chinese brambles and the early-ripening habit of certain of those already introduced have attracted the attention of plant breeders in this field, and the introduction of a species from the top of Mount Omei, on the Upper Yangtze, described by the sender, Dr. Edgar T. Shields, of Yachow, as "a delicious large yellow raspberry" can scarcely fail to attract their attention.

Two of the best fruits of the Malay Archipelago are the ramboetan and the kapoelasan, species of *Nephelium*. A Wardian-case shipment has been made from Java, containing three varieties of the latter (Nos. 28332 to 28334) and seven varieties of the former (Nos. 28335 to 28341), and an attempt will be made to propagate these on various stocks for distribution in Porto Rico, Hawaii, and the Panama Canal Zone.

Dr. L. Trabut, the veteran experimenter of Algiers, has sent in seeds of the remarkably alkali-resistant grass *Festuca fenas* (No. 28355) from the Shott Khreida.

A collection of medicagos and trifoliums from Beirut, Turkey, containing six species (Nos. 28788 to 28793) will be of use to those breeding these leguminous plants.

The khat plant of Yemen, on the west coast of Arabia, has been in cultivation for generations. Its fresh leaves are chewed by the Arabs almost universally in that region. To them life and hard work would be unendurable without khat, and every coolie, even the poorest, buys the leaf. The plant yields a marketable crop the sec-

ond year, is grown from cuttings, and is considered one of the most valuable cultures of the country. Plants have been secured and are now growing both from the Edinburgh Botanic Gardens and also direct from Aden, Arabia, through Mr. C. K. Moser, the American consul, who has furnished an interesting report on the industry. It is quite probable that this plant will grow in our southwestern country, but until the chemists and animal physiologists have closely examined the action of the alkaloid it contains, it will not be distributed to experimenters.

Picea breweriana of Oregon and California, which because of its appearance may be called the veiled spruce, is one of the rarest of all the spruces, and the seeds, though sought after many times, have so rarely been obtained that the distribution of more than a pound of fresh seed, received from Miss Alice Eastwood, is of unusual interest.

The nomenclature in this inventory and the notes on geographical distribution have been prepared in the Office of Taxonomic and Range Investigations by Mr. H. C. Skeels, under the direction of Mr. Frederick V. Coville. The inventory was prepared by Miss Mary A. Austin, of this office.

DAVID FAIRCHILD,
Agricultural Explorer in Charge.

OFFICE OF FOREIGN SEED AND PLANT INTRODUCTION,
Washington, D. C., April 24, 1911.

INVENTORY

28325 and 28326. AGAVE spp.

Zapupe.

From Tampico, Mexico. Purchased from Mr. Mordelo L. Vincent. Received July 5, 1910.

Suckers of the following:

28325. AGAVE LESPINASSEI Trelease.

Vincent. "A fiber-producing agave, similar in appearance to sisal, with leaves 4 to 5 feet long, light green, armed with reddish marginal spines. Yields its first crop of leaves for fiber three to five years after planting and annual or semiannual crops thereafter for three to five years. The fiber is of the same class as the sisal of commerce, but is finer and more flexible.

"This variety, developed on the island of Juana Ramirez, is regarded as one of the best of the half-dozen different kinds of zapupe cultivated in that region. It can be cultivated successfully only in places free from severe frost in winter."
(*Lyster H. Dewey.*)

28326. AGAVE ZAPUPE Trelease.

Estopier. "A fiber-producing agave, similar in appearance to the henequen cultivated in Yucatan, but with more slender leaves. The leaves are 4 to 5 feet long, glaucous, and with dark-reddish marginal spines. The first crop of leaves may be cut three to five years after planting and annually or semiannually thereafter for three to five years, when the plant will send up a flower stalk bearing bulbils and then die. It may be propagated by both bulbils and suckers. The fiber is similar to sisal and may be used for the same purposes, viz, binder twine and other hard-fiber twines.

"Cultivated most extensively in the vicinity of Tuxpam, Vera Cruz, Mexico, where it is called '*zapupe azul*' because of its bluish leaves. The variety *Estopier* has been improved somewhat by cultivation. Like all of the agaves cultivated for the production of fiber, it requires a climate practically free from frost."
(*Lyster H. Dewey.*)

28327. CATHA EDULIS Forsk.

Khat.

From Edinburgh, Scotland. Presented by the regius keeper, Royal Botanic Garden. Received July 5, 1910.

Plants. See No. 24714 for previous introduction, and No. 28825 for description.

28328 to 28330.

From Kandawglay, Rangoon, Burma, India. Presented by the secretary of the Agri-Horticultural Society of Burma. Received July 2, 1910.

Seeds of the following:

28328. PHYLANTHUS EMBLICA L.

Emblie myrobalan.

See No. 25724 for description.

28329. TERMINALIA BELLERICA (Gaertn.) Roxb.

Bellerie myrobalan.

See No. 25541 for description.

28330. TERMINALIA CHEBULA Retz.

Black myrobalan.

See No. 25542 for description.

28331. ANDROPOGON SQUARROSUS L. f.**Cuscus grass.**

From Peradeniya, Ceylon. Presented by Mr. M. Kelway Bamber, government chemist. Received July 2, 1910.

Clumps.

"This plant grows in large dense tufts, with stout, spongy, aromatic roots, which are sparingly branched. It is grown to a considerable extent in the hills of Jamaica for the purpose principally of binding loose soils and forming embankments on steep hill-sides to prevent washing by rains.

"In India the roots are used in making aromatic-scented mats, and also fans, baskets, and other articles. The roots also when distilled with water yield a fragrant oil which is used as a perfume. Used also as medicine in case of fever and bilious complaints." (Extract from *Botanical Department of Jamaica Bulletin B. S. vol. 7, 1900, pp. 152-153.*)

Distribution.—Throughout the plains and lower hills of India and Burma, rising to an elevation of 4,000 feet, and in Ceylon and Java, and tropical Africa.

28332 to 28341. NEPHELIUM spp.

From Buitenzorg, Java. Presented by the Director of Agriculture. Received July 2, 1910.

Plants of the following; notes by Mr. F. W. J. Westendorp in "Teysmannia," 1910:

28332 to 28334. NEPHELIUM MUTABILE Bl. **Kapoelasan.**

28334. *Si babat.* "Dark colored, almost black; not so common as some other varieties."

28335 to 28341. NEPHELIUM LAPPACEUM L. **Ramboetan.**

28335. *Atjeh lebak boeloes.* "This variety, a ramboetan of the second rank, is handled in large quantities."

28336. *Atjeh goela batoe.* "A variety of the first class, but can not be obtained in large quantities."

28337. *Atjeh tangkoeweh.*

28338. *Atjeh si konto.* The same remarks apply to this as to No. 28335.

28339. *Atjeh lengkeng.* **28340. *Si njonja.***

28341. *Atjeh matjan.*

"The two preceding ramboetans are of the first class and are the best commercial varieties."

For a general note on these fruits, see Nos. 25163 and 25165.

28342. COMBRETUM APICULATUM Sonder.

From Komati Poort, Transvaal, South Africa. Presented by Prof. J. Burt Davy, government agrostologist and botanist, Transvaal Department of Agriculture, Pretoria. Received July 5, 1910.

"Seed collected by me at an altitude of 600 feet. The climate is almost tropical and free from frost, the tamarind being grown there. I am not aware that this Combretum has any economic value beyond the fact that it is ornamental; it would be of interest in a tree collection in Florida, Louisiana, or southern California." (Davy.)

Distribution.—In the woods in the vicinity of Magaliesberg, in the Transvaal region of South Africa.

28343. DIOSPYROS MICROCARPA (Jacq.) Gurke.

From Sydney, New South Wales. Presented by Prof. J. H. Maiden, director and government botanist, Botanic Gardens. Received July 6, 1910.

"A large shrub or tree 20 to 40 or even 100 feet high; trunk sometimes 2 feet in diameter. Leaves oblong or oval, alternate, palish green, especially beneath. Flowers dioecious, tetramerous (or rarely trimerous). Fruit globular or ovoid, $\frac{1}{2}$ to $\frac{3}{4}$ inch thick, fuscous and glabrescent when ripe; edible; ultimately one-celled and one-seeded. Slender-growing tree with elongated trunk and elegant, rigid foliage. Wood close, very tough and firm." (*Extract from Hiern's Monograph of Ebenaceæ, in Transactions of the Cambridge Philosophical Society, vol. 12, p. 246.*)

Distribution.—In the forest region along the coast in New South Wales and Queensland, Australia.

28344. CROTALARIA CANDICANS Wight and Arnott.

From Poona, Bombay, India. Presented by Mr. P. S. Kanetkar, superintendent, Empress Botanical Gardens. Received July 9, 1910.

"This crop is used for green manuring in the Madras Presidency. Out of that presidency it is not known." (*Kanetkar.*)

"A copiously branched undershrub, attaining 4 feet in height, with short-petioled leaves and panicles of bright-yellow flowers, produced in great profusion at the beginning of January. It thrives in any fair garden soil and is propagated by seed." (*Extract from Woodrow's Gardening in India, p. 277.*)

Introduced for experimental growing as a cover crop, for breeding purposes, and as an ornamental in our Southern States.

Distribution.—Slopes of the Nilgiri and Madura Hills, in the southern part of India.

28345. VICIA FABA L.**Horse bean.**

From Dongola Province, Egypt. Presented by Mr. S. E. Durant, inspector of agriculture, at the request of the Director of Agriculture and Lands, Sudan Government, Khartum. Received July 7, 1910.

"This grain is never used for stock feed, but it is ground into flour and mixed with wheat flour, then baked into bread. The straw is fed to stock, the only preparation being that the grain is first thrashed out by hand. The natives do not consider that bean straw forms such a valuable fodder as that of wheat." (*Durant.*)

28346 to 28350. ORYZA SATIVA L.**Rice.**

From Philippine Islands. Received through Mr. William S. Lyon, Manila, July 1, 1910.

Seeds of the following; native names and notes as given by Mr. Lyon:

28346. *Inaplaya.* Matures in $4\frac{1}{2}$ months.

28347. *Inita.* One of the earliest; often matures in 100 days.

28348. *Dinalaga.* Late; matures in 4 to $4\frac{1}{2}$ months.

28349. *Minalit.* Very late; matures in 5 or more months.

28350. *Pimling-berto.* Medium; matures in 4 to $4\frac{1}{2}$ months.

28351. DIOSPYROS DISCOLOR Willd.**Mabola.**

From Buitenzorg, Java. Presented by the Director of Agriculture. Received July 14, 1910.

Seeds. See No. 26112 for description.

28352. DIOSPYROS sp.

From Baroda, Madras Presidency, India. Presented by Mr. B. S. Cavanaugh, superintendent, State Gardens. Received July 14, 1910.

Seeds.

28353. PASSIFLORA EDULIS Sims.

Passion flower.

From Madras Presidency, India. Presented by Mr. P. S. Kanetkar, superintendent, Empress Botanical Gardens, Poona, Bombay, India. Received July 14, 1910.

"Edible passion fruit grown for culinary purposes." (*Kanetkar.*)

28354. TERMINALIA CHEBULA Retz.

Black myrobalan.

From Baroda, India. Presented by Mr. B. S. Cavanaugh, superintendent, State Gardens. Received July 5, 1910.

See No. 25542 for description.

28355 and 28356.

From Algeria. Presented by Dr. L. Trabut, Algiers. Received July 5 and 11, 1910.

Seeds of the following; notes by Dr. Trabut:

28355. FESTUCA FENAS Lagasca.

"Grows in the very alkaline regions of Shott Khreida. This grass has a very remarkable resistance to alkalinity."

Distribution.—Southwestern Europe, extending from central Spain and southern France eastward to Croatia.

28356. VICIA FABA L.

Horse bean.

"Grows wild on the plateau of Sersou, Algeria."

28357. MELILOTUS SEGETALIS (Brot.) Ser.

From Maison Carree, Algeria. Presented by the Botanic Garden. Received July 5, 1910.

"This is a small, sparsely leaved annual melilot, native of Mediterranean Europe and Africa. It was originally described from Portugal. In former tests carried on by the Office of Forage-Crop Investigations of the Bureau of Plant Industry it has attained a height of only 10 to 15 inches and its small growth makes it of doubtful value for the United States. This melilot has been received previously under S. P. I. Nos. 17003 and 27473." (*H. N. Vinall.*)

28358. CROTALARIA CANDICANS Wight and Arnott.

From Sibpur, Calcutta, India. Presented by Maj. A. T. Gage, superintendent, Royal Botanic Garden. Received July 14, 1910.

See No. 28344 for description.

28359. MEDICAGO SATIVA L.

Alfalfa.

From Ecuador. Procured by Mr. Herman R. Dietrich, consul general, Guayaquil. Received July 14, 1910.

Guaranda.

28360 to 28363.

From Port Louis, Mauritius. Presented by Mr. G. Regnard. Received July 7, 1910.

Seeds of the following; notes by Mr. Regnard:

28360. *ERYTHROXYLON LAURIFOLIUM* Lam. "Mauritius torchwood."

Distribution.—A branching shrub common in the woods in the islands of Mauritius and Reunion and the Seychelles.

28361 and 28362. (Undetermined.) (Liliacæ.)

28361. "Blue fruited."

28362. "White fruited."

28363. (Undetermined.)

"Forest tree bearing scarlet berries."

28364. GOSSYPIUM sp.**Cotton.**

From Honduras. Presented by Mr. F. S. Chaffee, Trujillo, Honduras. Received July 8, 1910.

"This is supposed to be wild cotton from the Aguan River, 25 miles east of here (Trujillo). I found it three years ago while hunting in that vicinity. At that time it was a tree some 8 or 9 inches in diameter and 25 or 30 feet high and full of bloom. It stood out in the middle of a savannah in a sand and gravel soil with no other trees around it and fully a mile from any house. No one in that vicinity has any knowledge of its origin or how long it has been there; but last fall it was burned down by a savannah fire. These bolls were taken from the sprouts that have come up from the roots. There are also two or three other trees about a mile apart located in the heavy forest." (Chaffee.)

28365. TRITICUM AESTIVUM L.**Wheat.**

From near the shore of Lake Van, a few miles from Bitlis, Turkey in Asia.

Presented by Mr. Hamilton King, American minister to Siam, who procured it from Miss A. C. Ely. Received July 12, 1910.

"This is sown in drills and does not need to be irrigated. The soil is sandy, mixed with volcanic ashes, and probably some moisture percolates from the near-by lake. This is a rather inferior sample." (Ely.)

28367 and 28368.

From Marash, Turkey. Purchased from Mr. Paul N. Nersessian. Received July 16, 1910.

Seeds of the following; notes by Mr. Nersessian:

28367. *LATHYRUS SATIVUS* L.

"*Agh jilban* (white jilban). For cultivation, soil, and time and manner of sowing, see No. 28368."

28368. *VICIA ERVILIA* (L.) Willd.

Bitter vetch.

"*Koushne*. They do not cultivate these plants for green manuring but only for seeds which they use for cattle feed. The seed is sown here from about the middle of September until near the end of November. It sprouts or stools some in the fall and remains that way during the winter. In the spring it sprouts more, covers the ground perfectly, grows about a foot high, and is ripe enough to harvest in these days (about June 1?). Usually it is sown on poor or exhausted fields from which a good crop of grain can not be expected. Of course it does

28367 to 28368—Continued.

better in richer ground and especially in ground where potash predominates. The usual practice in sowing it around here is to irrigate the grain stubble field if there has not been rain enough, to sow nearly a bushel of seed to an acre right on the stubble and just cover the seeds with the old native plow, and then drag a pole over the field to smooth it somewhat, which of course helps the seeds to come up more evenly and also decreases the surface evaporation. It is sown broadcast. It likes the ground well drained, either naturally or artificially, and the earlier it is sown the better it is, within the time mentioned."

28369. BAMBOS ARUNDINACEA Retz.**Bamboo.**

From Sibpur, Calcutta, India. Purchased from Maj. A. T. Gage, superintendent, Royal Botanic Garden. Received July 16, 1910.

"This bamboo does not spread rapidly and it is seldom necessary to keep the plant in check. It never becomes a troublesome weed, and it can be extirpated without difficulty, if desired." (*Gage*.)

See No. 21317 for further description.

28370. PICEA BREWERIANA S. Watson.**Veiled spruce.**

From near Kerbyville, which is reached by stage from Grants Pass, Oreg. Collected by Mrs. A. J. Adams; purchased from Miss Alice Eastwood, Gray Herbarium, Harvard University, Cambridge, Mass. Received July, 1910.

"This is one of the rarest and most unique of all the spruces. It grows only on the summit of the Siskiyou Mountains of northern California and southern Oregon. I saw some small trees on Canyon Creek in Trinity County and I should call the tree the veiled spruce rather than the weeping spruce. It grows to quite a height, 70 or 80 feet, and with a diameter of 1 to 2 feet. The drooping branches are clothed with long pendent, slender branchlets. The tree is delicate and graceful in outline, but not funeral or sad. The cones resemble those of the Norway spruce." (*Eastwood*.)

Distribution.—Dry mountain ridges and peaks near the timber line on both slopes of the Siskiyou Mountains on the boundary between California and Oregon at an elevation of 7,000 feet, and on the Oregon coast ranges at the headwaters of the Illinois River, at an elevation of 4,000 to 5,000 feet.

28371 to 28531.

The following material presented by Dr. Walter Van Fleet to the Plant Introduction Garden, Chico, Cal. Numbered July, 1910. Notes by Dr. Van Fleet.

A collection made by Dr. Van Fleet, at Little Silver, N. J., and selected by him out of many thousands as especially valuable for breeding purposes in the various groups represented. Many of them are his own hybrids or crosses. The technical descriptions of the various species have been omitted for the sake of brevity.

28371. ALBIZZIA JULIBRISSIN Boiv.

(P. I. G. No. 6460.) "Seedlings from a tree 20 feet high growing in Monmouth County, N. J., little injured by winter temperatures as low as -12° F. Evidently a hardy type."

Distribution.—Mountains of northern Persia, India, northern China, and Japan; cultivated as an ornamental tree in Asia, southern Europe, northern Africa, and the United States.

28371 and 28531—Continued.**28372.** *ANTHOLYZA* sp.(P. I. G. No. 6225.) "Received from Natal, South Africa, as *Gladiolus* sp., possibly *Antholyza paniculata*."**28373.** *AQUILEGIA OXYSEPALA* × *CANADENSIS*.

(P. I. G. No. 6222.) "A hardy and long-lived hybrid, dwarf and early blooming; flowers wine red and white."

28374. *ZANTEDESCHIA ELLIOTTIANA* × *PENTLANDII*.

(P. I. G. No. 6534.) "A weak-growing hybrid; spathes pure golden yellow."

28375. *ZANTEDESCHIA REHMANNI* × *PENTLANDII*.

(P. I. G. No. 6533.) "Vigorous hybrids with lanceolate, spotted foliage; spathes pale yellow or white, overlaid with purple and rose shadings."

28376. *ZANTEDESCHIA REHMANNI* × *PENTLANDII*.

(P. I. G. No. 6299.)

28377. *AZALEA NUDIFLORA* × *SINENSIS*.

(P. I. G. No. 6442.) "Vigorous hybrids with profuse cream, rose and salmon colored blooms."

28378. × *BERBERIS STENOPHYLLA* Lindl.

(P. I. G. No. 6493.) "A very ornamental evergreen variety."

28379. *BERBERIS THUNBERGII* × *VULGARIS*.

(P. I. G. No. 6302.)

28380. *BERBERIS THUNBERGII* × *VULGARIS*.

(P. I. G. No. 6494.) "Third-generation plants from original hybridization."

28381. *CASTANEA PUMILA* × *SATIVA*.

(P. I. G. No. 6227.) This introduction had previously been assigned No. 26233, so the number 28381 will be discarded and 26233 used.

28382. *CELASTRUS ARTICULATUS* Thunb.(P. I. G. No. 6425.) *Distribution*.—In the provinces of Chihli, Shantung, Kiangsu, Kiangsi, Hupeh, and Kwangtung in China, in Chosen and the Korean and Nansei archipelagoes, and in the vicinities of Kiushu, Nagasaki, Yokosuka, Shimoda, and Hakodate in Japan.**28383.** *CITRUS TRIFOLIATA* L.

(P. I. G. No. 6447.) "Taken from a tree growing in Monmouth County, N. J. Has endured -8° F. without injury."

28384. *DEUTZIA SCABRA* × *DISCOLOR*.

(P. I. G. No. 6549.) "One-year seedlings."

28385. *FRAGARIA FILIPENDULA* Hemsl. (?)

(P. I. G. No. 6566.)

28386. *FRAGARIA INDICA* Andrews.

(P. I. G. No. 6567.)

28387. *FRAGARIA MOSCHATA* Duchesne. (?)

(P. I. G. No. 6573.)

28388. *FRAGARIA* sp.(P. I. G. No. 6568.) *Alfonso* × *filipendula*.**28389.** *FRAGARIA* sp.(P. I. G. No. 6219.) *Alfonso XIII* × *President*.

28371 to 28531—Continued.

28390 to 28396. *FREESIA REFRACTA* (Jacq.) Klatt.

28390. (P. I. G. No. 6211). "*× Freesia arbutus* (*F. leichlinii* *× armstrongi*)."

"An undisseminated hybrid; has large, sweet-scented, rosy lilac blooms, disposed in a conspicuous 2-ranked scape."

28391. (P. I. G. No. 6414). "*F. armstrongi* *×* commercial *Refracta alba*."

28392. (P. I. G. No. 6385). "*F. armstrongi* *× Purity* (*Refracta alba*)."

28393. (P. I. G. No. 6224). "*F. aurea* *×* (*chapmani* *× armstrongi*)."

28394. (P. I. G. No. 6450). "*F. chapmani* (*F. aurea* *× refracta*)."

"The finest yellow-flowered *Freesia*; raised in England."

28395. (P. I. G. No. 6196). "*F. refracta* *× armstrongi* (selected)."

28396. (P. I. G. No. 6213). "*F. refracta* *× armstrongi* (good variety)."

28397. *GERBERA JAMESONI* Bolus.

(P. I. G. No. 6461.) See No. 25513 for description.

28398. *GLADIOLUS ALATUS* L.

(P. I. G. No. 6206.) *Distribution*.—The southwestern provinces of Cape Colony and in Namaqualand, South Africa.

28399. *GLADIOLUS ALATUS* *×* *CARDINALIS*.

(P. I. G. No. 6215.)

28400. *GLADIOLUS ALATUS* *×* *COLVILLII* (*Delicatissima*).

(P. I. G. No. 6378.)

28401 to 28429. "Various undisseminated hybrid gladioli and parent species."

28401. *GLADIOLUS ALATUS* *×* *PRIMULINUS*.

(P. I. G. No. 6536.)

28402. *GLADIOLUS ALATUS* *×* *PRIMULINUS* (*Goldbug*).

(P. I. G. No. 6535.)

28403. *GLADIOLUS ALATUS* *×* *TRISTIS*.

(P. I. G. No. 6208.) "Green flowered."

28404. *GLADIOLUS BYZANTINUS* Miller.

(P. I. G. No. 6207.) Variety *albus*. *Distribution*.—The countries bordering on the Mediterranean Sea.

28405. *GLADIOLUS BYZANTINUS* (*albus*) *×* *PRIMULINUS*.

(P. I. G. No. 6199.)

28407. *GLADIOLUS CARDINALIS* Curtis.

(P. I. G. No. 6214.) *Queen Wilhelmina*.

28408. *GLADIOLUS CARDINALIS* *×* *GRANDIS*.

(P. I. G. No. 6203.)

28409. *GLADIOLUS CARDINALIS* *×* *PRIMULINUS*.

(P. I. G. No. 6386.)

28410. *GLADIOLUS COLVILLII* (*Bride*) *×* *PURPUREO-AURATUS* (*Klondike*).

(P. I. G. No. 6201.)

28371 to 28531—Continued.

28401 to 28429—Continued.

28411. *GLADIOLUS CRUENTUS* Moore.(P. I. G. No. 6524.) *Distribution*.—Known only from Natal on the east coast of South Africa.28412. *GLADIOLUS CRUENTUS* × a selected dark-red seedling.

(P. I. G. No. 6528.)

28413. *GLADIOLUS GRANDIS* × *ALATUS*.

(P. I. G. No. 6198.)

28414. *GLADIOLUS GRANDIS* × *PRIMULINUS*.

(P. I. G. No. 6200.)

28415. *GLADIOLUS PAPILIO* × "*Precious*."

(P. I. G. No. 6529.)

28416. *GLADIOLUS PRIMULINUS* × "*Goldbug*."

(P. I. G. No. 5527.)

28417. *GLADIOLUS PRIMULINUS* × *GRANDIS*.

(P. I. G. No. 6537.)

28418. *GLADIOLUS* sp. (No. 74) × *PRIMULINUS*.

(P. I. G. No. 6384.)

28419. *GLADIOLUS PSITTACINUS* × "*Very Odd*."

(P. I. G. No. 6530.)

28420. *GLADIOLUS PURPUREO-AURATUS* (*Klondike*) × *CARDINALIS* (*Delicatissima*).

(P. I. G. No. 6538.)

28421. *GLADIOLUS QUARTINIANUS* A. Rich.(P. I. G. No. 6526.) *Distribution*.—Mountains of tropical Africa from Abyssinia southward to Zambesia, Matabeleland, and Angola, rising to an elevation of 8,000 feet in Kassailand.28422. *GLADIOLUS QUARTINIANUS* × (?).

(P. I. G. No. 6531.)

28423. *GLADIOLUS RAMOSUS* (*Ne plus ultra*) × *COLVILLII* (*Express*).

(P. I. G. No. 6379.)

28424. *GLADIOLUS SALMONEUS* Baker.(P. I. G. No. 6525.) *Distribution*.—Occurs at an elevation of 4,800 feet on the mountain slopes in the vicinity of Kokstad, in Griqualand, eastern part of Cape Colony.28425. *GLADIOLUS SALMONEUS* × *QUARTINIANUS*.

(P. I. G. No. 6204.)

28426. *GLADIOLUS TRISTIS* × *COLVILLII*.

(P. I. G. No. 6377.)

28427. *GLADIOLUS TRISTIS* × *VITTATUS*.

(P. I. G. No. 6451.)

28428. *GLADIOLUS VITTATUS* × *PRIMULINUS*.

(P. I. G. No. 6197.)

28429. *GLADIOLUS WATSONIUS* × *GRANDIS*.

(P. I. G. No. 6202.)

28371 to 28531—Continued.

28430. *HIBISCUS SYRIACUS* L.

(P. I. G. No. 6546.) "A single-flowered, pure white seedling."

28431. *HEMEROCALLIS AURANTIACA* (MAJOR) $\times$ *CITRINA*.

(P. I. G. No. 6519.)

28432. *HEMEROCALLIS MAGNIFICA* Hort.

(P. I. G. No. 6300.)

28433. *HEMEROCALLIS MAGNIFICA* $\times$ *FLORHAM*.

(P. I. G. No. 6298.)

28434. *HIPPEASTRUM RUTILUM* $\times$ *VITTATUM*.

(P. I. G. No. 6423.) "Fine, red-flowered varieties, blooming when foliage is fully developed."

28435. *HIPPEASTRUM VITTATUM* $\times$ (?).

(P. I. G. No. 6413.)

28436. *IRIS ATROPURPUREA ATROPUSCA* Baker.

(P. I. G. No. 6397.)

28437. *IRIS ATROPURPUREA* Baker.

(P. I. G. No. 6458.) *Distribution*.—Imported from Syria.

28438. *IRIS BARTONI* Foster.

(P. I. G. No. 6469.) *Distribution*.—The vicinity of Kandahar in the southern part of Afghanistan.

28439. *IRIS BISMARCKIANA* Baker.

(P. I. G. No. 6402.) *Distribution*.—The province of Lebanon, on the coast of the Mediterranean Sea, in Asiatic Turkey.

28440. *IRIS CRISTATA* Soland.

(P. I. G. No. 6459.) *Distribution*.—Rich woods from Maryland to Georgia and westward to Ohio, Indiana, and Missouri.

28441. *IRIS DELAVAYI* $\times$ *SIBIRICA*.

(P. I. G. 6517.)

28442. *IRIS FULVA* Ker.

(P. I. G. No. 6516.) "A very large-flowered copper iris, bred by selection from the wild plant."

Distribution.—In swamps from Kentucky and Illinois southward to Missouri.

28443. *IRIS GRACILIPES* A. Gray.

(P. I. G. No. 6466.) *Distribution*.—In damp meadows in Nambu and in the vicinity of Hakodate on the island of Hokushu (Yezo), Japan.

28444. *IRIS GRANT-DUFFII* Baker.

(P. I. G. No. 6523.) *Distribution*.—Along the banks of the River Kishon in Palestine.

28445. *IRIS HELENÆ* Barbey.

(P. I. G. No. 6396.) *Distribution*.—In the vicinities of El Arish, Ouadi-el-Gradi, Ouadi-Cheriah, and Nachel Aboukeila, in the desert between Egypt and Palestine.

28446. *IRIS HEXAGONA* $\times$ *MISSOURIENSIS*.

(P. I. G. No. 6463.)

28371 to 28531—Continued.**28447. IRIS HIMALAICA Hort.**

(P. I. G. No. 6470.) Received in 1908 from Mr. W. R. Dykes, England. Not bloomed. This is probably *Iris clarkei* Baker, a native of Sikkim, India.

28448. IRIS LAEVIGATA Fisch.

(P. I. G. No. 6303.) *Distribution*.—In the vicinity of Yokosuka, Shimoda, and Hakodate in Japan; in the province of Shengking, China, and near Port Chusan in Chosen (Korea). Also extensively cultivated in other countries.

28449. IRIS KOROLKOWI Regel.

(P. I. G. No. 6401.) *Distribution*.—Sent alive by Gen. Korolkow to St. Petersburg in 1870 from Turkestan.

28450. IRIS PARADOXA × PUMILA.

(P. I. G. No. 6421.) "Very meritorious hybrids. Plants vigorous, free blooming, and of easy culture."

28451. IRIS LACUSTRIS Nutt.

(P. I. G. No. 6467.) *Distribution*.—Gravelly shores of Lakes Huron, Michigan, and Superior.

28452. IRIS LORTETII Barbey.

(P. I. G. No. 6399.) *Distribution*.—On the slopes of the Lebanon range of mountains at an altitude of 2,000 feet, between Mais and Hussin, in the province of Lebanon, Asiatic Turkey.

28453. IRIS MILESH × TECTORUM.

(P. I. G. No. 6380.)

28454. IRIS MILESH × TECTORUM.

(P. I. G. No. 6464.)

28455. IRIS MONNIERI DC.

(P. I. G. No. 6518.) *Distribution*.—The islands of Rhodes and Crete, in the eastern part of the Mediterranean.

28456. IRIS OBTUSIFOLIA Baker.

(P. I. G. No. 6520.) *Distribution*.—The province of Mazanderan, on the southern shore of the Caspian Sea, in Persia.

28457. IRIS PALLIDA Lam.

(P. I. G. No. 6462.) *Distribution*.—The islands of Crete and Rhodes, and in Palestine, Syria, and Morocco, rising to an elevation of 7,000 feet in the Atlas Mountains.

28458. IRIS NIGRICANS Hort.

(P. I. G. No. 6400.)

28459. IRIS PARADOXA × SAMBUCINA.

(P. I. G. No. 6465.)

28460. IRIS SIBIRICA × (?).

(P. I. G. No. 6446.)

28461. IRIS SIBIRICA × (?).

(P. I. G. No. 6521.)

28462. IRIS SIBIRICA × DELAVAYI.

(P. I. G. No. 6301.)

28371 to 28531—Continued.**28463.** *IRIS SOFARANA* Foster.(P. I. G. No. 6398.) *Distribution*.—On the Lebanon Mountains in the vicinity of Ain Sofar, Asiatic Turkey.**28464.** *IRIS STRAUSSI* Leichtl.(P. I. G. No. 6515.) *Distribution*.—The vicinity of Sultanabad, in the province of Irak Ajemi, western Persia.**28465.** *IRIS SUAVEOLENS* × *LUTESCENS* STATELLAE.

(P. I. G. No. 6220.)

28466. *IRIS TECTORUM* Maxim.(P. I. G. No. 6522.) *Distribution*.—The provinces of Shantung, Hupeh, Ichang, Hunan, Shensi, Kansu, and Szechwan, in China, and in the vicinity of Yokohama, in Japan.**28467.** *IRIS TECTORUM* × *MILESII*.

(P. I. G. No. 6221.)

28468. *IRIS TENAX* Dougl.(P. I. G. No. 6514.) *Distribution*.—Northwestern America, where it is common in open places from British Columbia southward to Oregon.**28469.** *IRIS TENAX* × *VERSICOLOR*.

(P. I. G. No. 6452.)

28470. *IRIS VERNA* L.(P. I. G. No. 6468.) *Distribution*.—Wooded hillsides from Pennsylvania to Kentucky and southward to Georgia and Alabama.**28471.** *IRIS VERSICOLOR* L.(P. I. G. No. 6445.) *Distribution*.—In swamps from Newfoundland to Manitoba and southward to Florida and Arkansas.**28472.** *JUGLANS CORDIFORMIS* Maxim.(P. I. G. No. 6449.) *Distribution*.—In the vicinity of Yokohama and of Hakodate on the island of Hokushu (Yezo), Japan.**28473.** *JUGLANS CORDIFORMIS* × *REGIA*.

(P. I. G. No. 6511.)

28474. *JUGLANS SIEBOLDIANA* Maxim.(P. I. G. No. 6448.) *Distribution*.—In forests on the mountains in Kiushu and in the vicinity of Tokyo, Yokohama, Kamakura, Yokosuka, and Hakodate, in Japan.**28475.** *LACHENALIA PENDULA* Ait.(P. I. G. No. 6192.) *Distribution*.—Along the coast of Cape Colony in the vicinity of Hout Bay and Cape Flats.**28476 to 28478.** *LACHENALIA PENDULA* × *TRICOLOR*.**28476.** (P. I. G. No. 6191.) *Cowslip*.**28477.** (P. I. G. No. 6193.) *Delight*.**28478.** (P. I. G. No. 6194.) *Rector of Cawston*.**28479.** *LACHENALIA TRICOLOR* Jacq.(P. I. G. No. 6195.) *Distribution*.—Along the coast of Cape Colony at Malmesbury, near Cape Town, Saldanha Bay, Cape Flats, and Port Elizabeth, South Africa.

28371 to 28531—Continued.

28480. *LATHYRUS LATIFOLIUS* L.

(P. I. G. No. 6491.) *Leichlin Extra White*.

28481. *LILIUM HENRYI* × *SPECIOSUM*.

(P. I. G. No. 6553.)

28482. *LILIUM HENRYI* × *SUPERBUM*.

(P. I. G. No. 6498.) "The largest flowered Hemerocallis."

28483. *LILIUM MACULATUM* × *MARTAGON*.

(P. I. G. No. 6552.)

28484. *LILIUM PHILIPPINENSE* × *LONGIFLORUM*.

(P. I. G. No. 6562.)

28485. *LILIUM PUBERULUM* × *LINIFOLIUM*.

(P. I. G. No. 6297.) "Very characteristic hybrids bearing large scarlet blooms of great substance, the small centers being yellow, dotted brownish purple. The other cross-pollinated lilies, as far as bloomed, do not show evidence of hybridity."

28486. *LILIUM SPECIOSUM* Thunb.

(P. I. G. No. 6381.) Variety *magnificum*.

28487. *LILIUM SPECIOSUM* × *HENRYI*.

(P. I. G. No. 6551.)

28488. *LILIUM* sp.

(P. I. G. No. 6382.) *Ellen Wilmot*.

28489. *MALUS BACCATA* × *SYLVESTRIS*.

(P. I. G. No. 6547.) "*MALUS BACCATA* × '*Baldwin*' × '*Yellow Transparent*.' Second-generation hybrids of considerable vigor."

28490. *NARCISSUS INCOMPARABILIS* × *POETICUS*.

(P. I. G. No. 6209.)

28491. *PAEONIA SUFFRUTICOSA* Andr.

(P. I. G. No. 6453.)

28492. *PAEONIA* sp.

(P. I. G. No. 6454.) Seedling varieties.

28493. *PHILADELPHUS CORONARIUS* × *MICROPHYLLUS*.

(P. I. G. No. 6495.)

28494. *PHILADELPHUS CORONARIUS* L.

(P. I. G. No. 6492.)

28495. *PLATYCODON GRANDIFLORUM* (Jacq.) DC.

(P. I. G. No. 6432.) Variety *Mariesi macranthum*.

28496. *PRUNUS SIMONII* × *AMERICANA*.

(P. I. G. No. 6548.)

28497. *PYRUS CHINENSIS* × *COMMUNIS*.

(P. I. G. No. 6510.) Chinese varieties, *Kieffer*, *Le Conte*, and *Golden Russet*, pollinated with *Bartlett*, *Angouleme*, *Anjou*, *Seckel*, and *Lawrence*.

28498. *QUAMASIA LEICHTLINII* × *CUSICKII*.

(P. I. G. No. 6223.)

28371 to 28531—Continued.

28499 to 28503. Promising hybrids between native gooseberry species and European garden varieties.

28499. *RIBES CYNOSBATI* × *RECLINATUM*.

(P. I. G. No. 6565.)

28500. *RIBES MISSOURIENSE* × *RECLINATUM*.

(P. I. G. No. 6217.)

28501. *RIBES MISSOURIENSE* × *RECLINATUM*.

(P. I. G. No. 6563.)

28502. *RIBES MISSOURIENSE* × *RECLINATUM* × *ROTUNDIFOLIUM*.

(P. I. G. No. 6218.)

28503. *RIBES RECLINATUM* × *ROTUNDIFOLIUM*

(P. I. G. No. 6564.)

28504. *ROSA CHINENSIS* Jacq.

(P. I. G. No. 6443.) *Distribution*.—The provinces of Hupeh and Kwangtung, in China, and the island of Formosa.

28505. *ROSA LAEVIGATA* × *Frau Karl Druschki*.

(P. I. G. No. 6422.) "Attractive hardy hybrids bearing large semidouble sweet-scented blooms, bluish white in color."

28506. *ROSA FERRUGINEA* × *Paul Neyron*.

(P. I. G. No. 6456.) "Nearly thornless variety with reddish foliage; bloom very double, medium in size, bright rose pink in color."

28507. *ROSA LUTEA* × *Harrison's Yellow*.

(P. I. G. No. 6543.) "Very striking; buds nasturtium scarlet; blooms when opening light orange, turning to white and then to bluish pink; semidouble, 2 inches across."

28508. *ROSA MULTIFLORA* × *LUTEA*.

(P. I. G. No. 6455.)

28509. *ROSA RUGOSA* × *CHINENSIS*.

(P. I. G. No. 6539.) *Victor Hugo*. "Profuse, large, double, sweet-scented blooms, fiery scarlet-crimson in color. Apparently the best *Rosa rugosa* hybrid."

28510. *ROSA RUGOSA* (ALBA) × *CHINENSIS* (*Devoniensis*).

(P. I. G. No. 6540.) "Good double white Rugosa, resembling Mad. Georges Bruant."

28511. *ROSA RUGOSA* × *Ards Rover*.

(P. I. G. No. 6497.)

28512. *ROSA RUGOSA* × ?.

(P. I. G. No. 6305.)

28513. *ROSA RUGOSA* × ?.

(P. I. G. No. 6541.) *Souvenir de Pierre Lepredieuz*.

28514. *ROSA SOULIEANA* Crepin.

(P. I. G. No. 6569.) *Distribution*.—In the vicinity of Tatsienlu, in the province of Szechwan, western China.

28515. *ROSA* sp.

(P. I. G. No. 6544.) "Hybrids of *Crimson Rambler*."

28371 to 28531—Continued.**28516.** *ROSA* sp.(P. I. G. No. 6545.) *Lyon.***28517.** *ROSA* sp.(P. I. G. No. 6417.) "*Lyon* × *President Carnot.*"**28518.** *ROSA* sp.(P. I. G. No. 6542.) *Richmond.***28519.** *ROSA* sp.(P. I. G. No. 6496.) *Victor Hugo.* (Hybrid *Remontant.*)**28520.** *ROSA* spp. Miscellaneous fruits.

(P. I. G. No. 6304.)

28521. *ROSA* spp. Seeds of hardy roses.

(P. I. G. No. 6428.)

28522. *ROSA* spp. Miscellaneous fruits.

(P. I. G. No. 6444.)

28523 and 28524. "Promising crossbred garden raspberries."**28523.** *RUBUS NEGLECTUS* × *IDAEOUS.*

(P. I. G. No. 6571.)

28524. *RUBUS NEGLECTUS* × *STRIGOSUS.*

(P. I. G. No. 6572.)

28525. *TRITOMA NORTHIAE* (Baker) Skeels.(*Kniphofia northiae* Baker, Jour. Bot., vol. 27, p. 43, 1889.)

(P. I. G. No. 6509.)

28526. *TRITOMA TUCKII* (Baker) Skeels.(*Kniphofia tuckii* Baker, Gard. Chron., ser. 3, vol. 13, p. 68, 1893.)

The generic name *Kniphofia* was applied by Moench in 1794 (Meth., p. 632) to *Aletris uvaria* L., a species belonging to the same genus as the two given above, but *Kniphofia* had been published by Scopoli in 1777 (Introd., p. 327) as a generic name for *Terminalia catappa* L., and was therefore invalid as a designation for the other and later genus.

The next earliest name available for this genus is *Tritoma*, which was published by Ker-Gawler in 1804 (Botanical Magazine, vol. 20, pl. 744), based on *Tritoma sarmentosa* (Andrews) Skeels (*Aletris sarmentosa* Andrews), a South African species belonging to the same genus as the two listed above. These species are therefore recognized under the name given to the genus by Ker-Gawler, a name perhaps more frequently applied to them in horticultural literature than *Kniphofia*.

These plants are both indigenous to Cape Colony, *Tritoma northiae* occurring near Grahamstown, in the Albany division of the coast region, and *Tritoma tuckii* in the Colesberg division of the central region.

28527. × *TRITONIA* "*Prometheus.*"

(P. I. G. No. 6427.)

28528. *VITIS VINIFERA* × (*AESTIVALIS* × *LABRUSCA*).(P. I. G. No. 6418.) *Black Hamburg* × *Gold Coin.*

28371 to 28531—Continued.**28529. YUCCA FILAMENTOSA L.**(P. I. G. No. 6419.) Variety *variegata*.*Distribution*.—In dry and sandy soil from North Carolina to Florida and Mississippi.**28530. YUCCA FLACCIDA Haw.**(P. I. G. No. 6306.) *Distribution*.—On dry or sandy slopes in or near the mountains from North Carolina to Alabama.**28531. ZEPHYRANTHES SULPHUREA Hort.**

(P. I. G. No. 6216.)

28532. MEDICAGO CARSTIENSIS Wulfen.

From Edinburgh, Scotland. Presented by Dr. Isaac Bayley Balfour, director, Royal Botanic Garden. Received July 21, 1910.

See No. 27794 for previous introduction.

28533 to 28536. CARICA PAPAYA L.**Papaya.**

From Empire, Canal Zone, Panama. Presented by Mr. W. G. Ross, at the request of Mr. H. F. Schultz. Received July 21, 1910.

Seeds of the following:

28533. "Fruit cylindrical in shape, very rich flavor, heaviest one here weighing 16½ pounds." (Ross.)

"This variety has a very small seed cavity and less seeds than most others." (Schultz.)

28534. "Fruit oblong in shape, extra size, 10½ pounds, and having an excellent flavor." (Ross.)**28535.** "Fruit oblong and slightly tapering in shape, above medium in size, and having very sweet meat." (Ross.)**28536.** "Fruit pear shaped. Tree was planted three years ago and produced 30 papayas last year, all very large and of very fine flavor." (Ross.)**28537. TRICHOLAENA ROSEA Nees.**

From Benguela, Angola, Portuguese West Africa. Presented by Mr. T. W. Woodside, A. B. C. F. M. Received July 20, 1910.

"A grass that grows spontaneously in old worn-out fields. Grows often to the height of 2½ or 3 feet. It is very succulent and sweet, and cattle like it very much. From the fact that it grows in old abandoned fields I would judge that it does not require rich soil." (Woodside.)

28538 and 28539. MEDICAGO SATIVA L.**Alfalfa.**

From the Bombay Presidency, India. Presented by Mr. P. S. Kanetkar, superintendent, Empress Botanical Gardens, Poona, Bombay, India. Received July 23, 1910.

Seeds of the following:

28538. "From the Surat district, a few miles from the sea and at sea level. It is grown in fields in which sugar cane was grown in the rains and harvested in October. The seed is sown in November. No cuttings for green fodder are taken, but the crop is allowed to run to flower and seed. The crop is harvested at the end of March. The cultivators near Surat have only recently taken

28538 to 28539—Continued.

to growing lucern for seed only. The crop from this seed, however, is not as lasting a one as from the seed of the following (S. P. I. No. 28539)."
(*Kanetkar.*)

28539. "From Poona, which is situated at a height of 1,900 feet and is distant 80 miles from the sea. The soil is loamy and responds to manure and irrigation treatments readily. The lucern crop in Poona is kept for three years, the cuttings which are taken every four to five weeks being fed to cattle and horses. The plants are allowed to run to seed in March every year. The seeds are sold at about triple the price of seed of the preceding (S. P. I. No. 28538). A quart bottleful is sold at from 2 to 2½ rupees, a rupee being equal to 16 pence." (*Kanetkar.*)

28540 to 28550.

From Pretoria, Transvaal, South Africa. Presented by Prof. J. Burtt Davy, government agrostologist and botanist, Transvaal Department of Agriculture. Received July 23, 1910.

Seeds of the following:

28540. *TRICHLORIS MENDOCINA* (Phil.) Kurtz.

See No. 26651 for previous introduction.

28541. *CERVICINA UNDULATA* (L. f.) Skeels.

See No. 27520 for previous introduction.

28542. *ERAGROSTIS LAPPULA DIVARICATA* Stapf.

Distribution.—On the Pellat Plains, between Matlareen River and Takun, in Bechuanaland, South Africa.

28543. *TRisetum SPICATUM* (L.) Richter.

Distribution.—Alpine regions and in the Arctic and Antarctic zones.

28544. *CHAETOCHLOA NIGRIROSTRIS* (Nees) Skeels.

See No. 26653 for previous introduction.

28545. *ERAGROSTIS PLANA* Nees.

Distribution.—In the Kalahari district and along the eastern coast of Cape Colony and Natal in South Africa.

28546. *PANICUM MAXIMUM HIRSUTISSIMUM* Nees.

(*Panicum hirsutissimum* Steud.)

Distribution.—The coast region of Natal and Cape Colony.

28547. *SPINIFEX HIRSUTUS* Labill.

Distribution.—Sandy shores of New Zealand, Tasmania, and southern Australia.

28548. *TRICHLORIS MENDOCINA* (Phil.) Kurtz.

See No. 28540 for previous introduction.

28549. *ERAGROSTIS GUMMIFLUA* Nees.

Distribution.—South Africa; in the Kalahari region and along the eastern coast of Cape Colony and Natal.

28550. *ACACIA ROBUSTA* Burchell.

"This is a characteristic tree of the dry bush veldt below 4,500 feet altitude (i. e., in the subtropical zone of the Transvaal).

28540 to 28550—Continued.

"I have not been able to learn much about the wood, beyond the fact that it is sometimes used for fence posts when the rarer and harder sorts, such as *Olea verrucosa*, are not available." (*Davy.*)

Distribution.—In the vicinity of Litakun, Bechuanaland, and at Magaliesberg in the interior of Cape Colony.

28551. MANGIFERA INDICA L.**Mango.**

From Monrovia, Liberia, West Africa. Presented by Mr. E. L. Parker, Commissioner of Agriculture. Received July 20, 1910.

Sierra Leone.

28552 to 28555. MANGIFERA INDICA L.**Mango.**

From Poona, Bombay, India. Purchased from Mr. P. S. Kanetkar, superintendent, Empress Botanical Gardens. Received July 20, 1910.

Seeds of the following:

28552. *Alphonse.*

28554. *Pakria.*

28553. *Kadarapasant.*

28555. *Totafari.*

28556 to 28563. MANGIFERA INDICA L.**Mango.**

From Sibpur, Calcutta, India. Purchased from Maj. A. T. Gage, superintendent, Royal Botanic Garden. Received July 20, 1910.

Seeds of the following:

28556. *Alphonso.*

28560. *Small Malda.*

28557. *Baromassia.*

28561. *Paranay.*

28558. *Bhadoorea.*

28562. *Peters.*

28559. *Large Malda.*

28563. *Soondershaw.*

28564 to 28568. MANGIFERA INDICA L.**Mango.**

From Colombo, Ceylon. Purchased from Dr. C. Driberg, secretary, Ceylon Agricultural Society. Received July 22, 1910.

Seeds of the following; descriptive notes by Dr. Driberg:

28564. *Dampara.* "Prolific; fruit small in size, of second quality, rather fibrous; skin yellow brown; seed small; ripens early and keeps fairly well. The tree is a free grower and is hardy. It is not much cultivated."

28565. *Heart.* "This is also called *Bombay* and is the commonest variety found on the market. Prolific; fruit medium in size, not much longer than broad, of second quality; skin golden yellow; seed of medium size; ripens early and is a fair keeper. The tree is a free grower and is hardy."

28566. *Jaffna.* "The favorite variety here. Prolific; fruit medium in size, twice as long as broad, of first quality; skin green; seed of medium size; ripens early and is a fair keeper. The tree is a fairly free grower and is hardy."

28567. *Parrot.* "Fairly prolific; fruit medium to small, of second quality; skin dark green; seed of medium size; ripens late and is a fair keeper. The tree is a free grower and is hardy. This variety has a slight turpentine flavor and is not very common."

28564 to 28568—Continued.

28568. *Rupee*. "This is also called '*Two-Shilling*.' It is a sparse bearer; fruit the largest of local (Ceylon) varieties, of first quality; skin pale green; seed small compared to size of fruit; ripens late and is not a good keeper. The tree is not a free grower and is tender. This variety is scarce and expensive. Requires very careful ripening."

28569 to 28582. MUSA spp.**Banana.**

From Paramaribo, Surinam. Presented by Mr. Goldsmith H. Williams, manager, United Fruit Co. Received July 21, 1910.

Suckers of the following; notes by Mr. Williams:

28569 to 28580. MUSA sp.

28569. "*Bas Joe*. From southern China. Has seeds in very small fruit."

28570. "*Cinerea Sahramphur*. Short, slim-pointed fruit of good flavor."

28571. "*Congo*."

28572. "Dwarf banana, frequently called *Cavendishii*."

28573. "Jamaica banana."

28574. "Large *Horse* banana. Sweeter than the plantain. Very good fried or roasted."

28575. "*Pisang Ambon*. A trifle better than the *Horse* banana of Florida and much the same shape."

28576. "*Pisang Celat*. Small, sweet fruit with 13 to 16 hands on a bunch."

28577. "*Pisang Kudjo*. Red banana."

28578. "*Pisang Siam*. Much like the *Horse* banana of Florida."

28579. "*Pisang Susa*. Similar to the ordinary *Apple* banana."

28580. "*Rubra India Sapientum Dacca*. One of the silver-skin varieties. What we term silver skin is a fruit that is like the red banana in shape and flavor, but with a clear, yellow skin."

28581. MUSA ROSACEA Jacq.

"Variety *Chittagong*. Very small, with seeds. New York Botanical Garden No. 9636."

Distribution.—The lower slopes of the eastern Himalayas in Chittagong, upper Burma, and in the Konkan region on the western coast of India; said to have been introduced from Mauritius in 1805.

28582. MUSA ZEBRINA Van Houtte.

"Reddish leaves. Very small worthless fruit, with seeds. Good as an ornamental plant."

28583. ARRACACIA XANTHORRHIZA Bancroft.**Arracacha.**

From Caracas, Venezuela. Presented by Señor Antonio Valero Lara. Received July 26, 1910.

See No. 3511 for description.

28584. DIOSPYROS PEREGRINA (Gaertn.) Guerke.

From Sibpur, Calcutta, India. Presented by Maj. A. T. Gage, superintendent, Royal Botanic Garden. Received July 26, 1910.

"A dense, evergreen, small tree with dark-green foliage and long, shining leaves; common throughout India and Burma except the arid and dry zone in the Punjab and Sind. Distributed to Ceylon, Siam, and the Malay Peninsula; very abundant in Bengal. It is a beautiful tree; the fruit is eatable, but excessively sour. Its principal use is for paying the bottoms of boats. It is beaten in a large mortar and the juice is expressed. This is boiled, mixed with powdered charcoal, and applied once a year to the outside of the planks. The wood is of little value. The fruit is largely used in tanning, being a powerful astringent. The juice of the unripe fruit is used in medicine as an astringent. The tree produces a round fruit as big as a middle-sized apple, green when unripe, rusty yellow when ripe, and in the later stages containing a somewhat astringent pulp, in which the seeds are embedded. When ripe it is eaten by the natives, but is not very palatable. The leaves are also eaten as a vegetable. Ainslie mentions that the carpenters of the Malabar coast use the juice of the fruit as an excellent glue." (*Watt, Dictionary of the Economic Products of India, vol. 3, p. 145.*)

Seeds.

28585 to 28593.

From Domäne Niemiercze, Podolia, Russia. Presented by Messrs. K. Buszczynski and M. Lazynski. Received July 22, 1910.

Seeds of the following:

28585 to 28587. AVENA SATIVA L.

Oat.

28585. *Earliest, or Sixty-Day.*

28586. *Ligovo.*

28587. The new oats (cross between *Ligovo* and *Earliest*).

28588 to 28592. TRITICUM AESTIVUM L.

Wheat.

28588. Brown bearded.

28591. *Triumph of Podolia.*

28589. *Crossed Wheat No. 1.*

28592. White bearded.

28590. *Improved Banat.*

28593. TRITICUM DURUM Deef.

Wheat.

White spring.

28594 and 28595.

From Spain. Presented by Mr. R. L. Sprague, American consul, Gibraltar, Spain. Received July 7, 1910.

Seeds of the following; notes by Mr. Sprague:

28594. VICIA ERVILIA (L.) Willd.

Bitter vetch.

"Yero. This vetch is sown throughout Andalusia, but never plowed under for green manure. When the crop is ripe it is gathered and given to cattle during the winter months."

28595. LATHYRUS SATIVUS L.

"*Alverjones*. These are used for green manure and can be procured in larger quantities than the preceding (S. P. I. No. 28594). At about the same price the practical result is considered better."

28596. HORDEUM sp.**Barley.**

From Maison Carree, Algeria. Presented by Dr. L. Trabut, Algiers, Algeria.
Received July 27, 1910.

"Smooth-bearded black barley. This barley appeared as a mutation in some black barley from Australia; it is very early and very resistant to drought. Curious on account of its absolutely smooth beards." (*Trabut.*)

28597. ALEURITES MOLUCCANA (L.) Willd.**Candlenut.**

From Manila, Philippine Islands. Presented by Mr. William S. Lyon. Received July 21, 1910.

See No. 24351 for description.

28598 to 28603. ALLIUM CEPA L.**Onion.**

From Puerto de Orotava, Teneriffe, Canary Islands. Presented by Mr. Solomon Berliner, American consul, Teneriffe. Received July 27, 1910.

Seeds of the following:

28598 to 28600. From Wildpret Bros. (Specially selected seed.)

28598. *Bermuda Red.*

28600. *Crystal Wax.*

28599. *Bermuda White.*

28601 to 28603. From Mr. T. M. Reid.

28601. *Bermuda Red.*

28603. *Crystal Wax.*

28602. *Bermuda White.*

28604. CICER ARIETINUM L.**Chick-pea.**

From Byers, Colo. Procured by Mr. H. N. Vinall from Mr. Edelen. Received July 29, 1910.

"Mr. Edelen says the original seed of these peas was given to him by an Italian. He claims they yielded 2,500 pounds of grain per acre last season, and in the face of an extremely dry season this year he is counting on 1,000 pounds per acre. From the looks of his field I should judge that 500 or 600 pounds is nearer what the correct yield will be. Chick-peas are very drought resistant and hail does them little injury, as the plant itself is tough and fibrous." (*Vinall.*)

28606. CROTALARIA CANDICANS Wight and Arnott.

From Peradeniya, Ceylon. Presented by Dr. J. C. Willis, director, Botanic Garden. Received August 2, 1910.

See No. 28344 for description.

28607. DENDROCALAMUS STRICTUS (Roxb.) Nees.**Bamboo.**

From Sibpur, near Calcutta, India. Presented by Maj. A. T. Gage, superintendent, Royal Botanic Garden. Received August 5, 1910.

See Nos. 21548, 22819, and 23476 for previous introductions.

28609. MYRICA NAGI Thunb.

From Kiayingchau, China. Presented by Mr. George Campbell. Received July 25, 1910.

Seeds. See Nos. 25908 and 26905 for previous introductions.

28610 and 28611. ANONA spp.

From Redland Bay, Queensland, Australia. Presented by Mr. James Collins.
Received August 2, 1910.

Cuttings of the following:

28610. ANONA sp.

"As far as I know this variety has never been named. It is a giant and far superior to any of the other anonas. It often attains a weight of 6 pounds, 'being a veritable custard.' It originated here about 30 years ago." (*Collins.*)

28611. ANONA CHERIMOLA Mill.

Cherimoya.

28612 and 28613. MANGIFERA INDICA L.

Mango.

From Poona, Bombay, India. Purchased from Mr. P. S. Kanetkar, superintendent, Empress Botanical Gardens. Received August 4, 1910.

Seeds of the following:

28612. *Pyrie.*

28613. *Kala Hapoos.*

28614 and 28615. ZEA MAYS L.

Corn.

From the Kalahari, about 30 miles east of Kuruman, on the Kaapscheberg, South Bechuanaland, Africa. Presented by Prof. J. Burtt Davy, government agrostologist and botanist, Transvaal Department of Agriculture, Pretoria, Transvaal, South Africa. Received August 2, 1910.

Seeds of the following; notes by Prof. Davy:

"*White Botman* flint maize. This seed was procured from a very dry region, of shallow limestone soil, cold and dry in winter. It struck me that these strains might do for the extreme southwest of the corn belt of the United States (northwestern Texas)."

28614. "Donovan's strain (red cob) has been grown by him without selection or change of seed for 10 years, and came originally from a still drier region, Daniels Kuil, at the southeast end of the Kuruman Hills."

28615. "Mayer's strain, from the same vicinity as the preceding (S. P. I. No. 28614)."

28616. TRICHILIA DREGEANA E. Meyer.

From Durban, Natal, South Africa. Presented by Dr. J. Medley Wood, director, Botanic Gardens. Received July 26, 1910.

"A handsome evergreen shade tree." (*Wood.*)

Distribution.—In woods in the vicinity of Durban in South Africa.

See No. 9482 for previous introduction.

28617. VIGNA UNGUICULATA (L.) Walp.

Cowpea.

From Para, Brazil. Presented by Mr. Walter Fischer, acting director, Campo de Cultura Experimental Paraense. Received August 4, 1910.

"Probably identical with the *Blackeye* variety; I grew them on the campo and harvested them just two months after sowing. This cowpea could hardly be called a forage variety, at least not here in this soil, where it soon goes to seed, but bears heavily." (*Fischer.*)

28618 to 28625.

From Russia. Received through Mr. Frank N. Meyer, agricultural explorer, July 25, 1910.

28618 to 28625—Continued.

Seeds of the following:

28618. LATHYRUS SATIVUS L.

From Vladikavkaz, Caucasus, Russia. "(No. 1334a, May 4, 1910.) A legume very rarely seen, said to come originally from Russia. The seeds are used locally as a human food, being boiled in soups or mixed with chick-peas in stews. Suitable for trial as a forage crop in regions with a moderately light summer rainfall." (*Meyer.*)

28619. PISUM SATIVUM L.

Field pea.

From Vladikavkaz, Caucasus, Russia. "(No. 1335a, May 4, 1910.) A very small pea, apparently an offspring from a cross between *Pisum sativum* and *Pisum arvense*. Used locally as a food, being more appreciated than the large-seeded varieties and consequently more expensive. Perhaps of value as a forage or food crop in the intermountain regions." (*Meyer.*)

28620. CICER ARIETINUM L.

Chick-pea.

From Baku, Caucasus, Russia. "(No. 1336a, May 23, 1910.) A large variety of chick-pea, obtained from a Persian seed dealer and said to come from Persia. Chick-peas are much used by the orientals, preferably boiled with mutton in soups and stews." (*Meyer.*)

28621. VICIA FABA L.

Horse bean.

From Baku, Caucasus, Russia. "(No. 1337a, May 23, 1910.) A horse bean, said to come from Persia. Used by the orientals both in the fresh green and in the dried state as a vegetable. Ground horse beans are a well-known and excellent feed for draft animals; perhaps they may be grown advantageously as a winter crop in the mild-wintered regions of the United States and as a summer crop in the intermountain regions." (*Meyer.*)

28622. TRITICUM DURUM Desf.

Wheat.

From Baku, Caucasus, Russia. "(No. 1338a, May 23, 1910.) A good hard wheat, said to come from Persia." (*Meyer.*)

28623. TRITICUM DURUM Desf.

Wheat.

From Vladikavkaz, Caucasus, Russia. "(No. 1339a, May 4, 1910.) An excellent hard wheat, coming from Persia and called '*Tatuch*.'" (*Meyer.*)

28624. HORDEUM sp.

Hull-less barley.

From Baku, Caucasus, Russia. "(No. 1340a, May 23, 1910.) A naked barley of superior quality, said to come from Persia. Much imported into this country, where it is roasted and mixed with coffee. The beverage produced from this is very agreeable." (*Meyer.*)

28625. LENS ESCULENTA Moench.

Lentil.

From Baku, Caucasus, Russia. "(No. 1341a, May 23, 1910.) A large variety of lentil, said to come from Persia. Much used by the orientals in soups and stews. Recommended as a crop in semiarid regions." (*Meyer.*)

28626. OPUNTIA sp.

From Nice, France. Presented by Dr. A. Robertson-Proschowsky. Received at the Subtropical Plant Introduction Garden, Miami, Fla., in the spring of 1909. Numbered for convenience in recording distribution on August 12, 1910.

"This *Opuntia* is easily propagated by cuttings of the pads. After being severed from the plant, they should be left in the sun for two or three days to dry up the

28626—Continued.

wound and then be planted rather deeply in the ground in comparatively dry soil. Because of the value of its fruits it seems that this species is likely to prove a very valuable one for dry soils where other plants are not likely to thrive." (*Robertson-Proschowsky, Journal d'Agriculture Tropicale.*)

28627 to 28631. MANGIFERA INDICA L.**Mango.**

From India. Purchased from Mr. P. S. Kanetkar, superintendent, Empress Botanical Gardens, Poona, Bombay. Received August 8, 1910.

Seeds of the following:

- 28627. *Amin*. From Madras Presidency.
- 28628. *Borsha*. From Poona.
- 28629. *Fernandez*. From Goa.
- 28630. *Peter pasant*. From Madras Presidency.
- 28631. *Shendrya*. From (Kothrud) Poona.

28632 and 28633. CAPSICUM ANNUUM L.**Pepper.**

From Sibpur, near Calcutta, India. Presented by Maj. A. T. Gage, superintendent, Royal Botanic Garden. Received August 2, 1910.

Seed of *Nepal* peppers from northern India, as follows:

- 28632. Red.
- 28633. Yellow.

28634 to 28636.

From Chile. Received through Mr. José D. Husbands, Limavida, Chile, August 3, 1910.

Seeds of the following; descriptive notes by Mr. Husbands:

28634. CHENOPodium QUINOA Willd.**Quinoa.**

"(No. 585.) A grain said to produce 1,000 for 1. After rubbing and washing well to remove its bitterness it is eaten boiled, toasted, and ground into flour, used in soups, etc. The ashes of the plant contain an extra amount of potash and are used in soap making."

28635. MYRTUS sp.

"(No. 590.) A new class of '*Arrayan*,' a *Myrtus* that flowers in the fall, has crimson seed berries, and seeks the altitude of the driest arid hills; the fragrance is about the same as of that which flowers in the spring and only grows in wet or moist places. A dense, evergreen, ornamental treelet or bush worthy of cultivation."

28636. PERSEA MEYENIANA Nees.

"(No. 584.) '*Lingue*' of central Chile."

28637 to 28642. VITIS VINIFERA L.**Grape.**

From Elqui, Chile. Received through Mr. José D. Husbands, Limavida, Chile, August 11, 1910.

28637 and 28638. "*Italia*. This is the finest raisin grape known." (*Husbands.*)

28637 to 28642—Continued.**28637 and 28638—Continued.****28637. Seeds.****28638. Cuttings.**

"While I can not speak authoritatively upon the subject, I will give my opinion, which I believe will be found substantially correct upon investigation. Elqui raisins are made from the 'Italia' grapes. These are lemon yellow in color, long-oblong in shape, agreeably sweet, exquisitely flavored, have thin skins and semitransparent, long, slender bunches, a fruit which makes excellent raisins even when left hanging on the vine after maturity. The seeds vary. Some fruits are seedless; others in the same bunch have chaff seeds; others one, two, three, and rarely, but sometimes, more. I think neither machines nor shade are employed in drying raisins in Chile, nor are they steeped in boiling water or any sort of lye, nor are they dried on the plant. They are simply picked and sundried upon mats, trays, or shallow baskets. Their flexibility is natural and not due to sweating. The natural dryness of the climate is quite sufficient to dry them to perfection either in the shade or sun. The latter method is quicker and better, as it leaves the raisins softer. These vines are prolific bearers and the grapes are highly esteemed as extra fine and juicy table grapes.

"In view of the fact that all fruits, grains, etc., of a similar appearance are vulgarly called the same, I have an idea that the Elqui Italia is, or may be, a class by itself, a Chile strain of the Italias introduced from Italy. I have seen very many kinds of Italia grapes grown in central Chile, principally for consumption while fresh. There are other classes preferred for wines and brandy. All these have the same general appearance and are called alike, but show marked differences in plant and fruit. The Elqui grape for making raisins, however, is above competition." (*Husbands.*)

28639 and 28640. "Pastilla. It is from these grapes that the famous Chile brandy called 'Pisco' is distilled." (*Husbands.*)

28639. Seeds.**28640. Cuttings.**

"Pisco originated at a seaport just south of Callao, Peru, named Pisco. The liquor was sold in a jar about 30 inches high, mouth about 6 inches in diameter made so that it could not stand up. This jar was made by the Spanish upon models of the Incas. The brandy was placed within this piece of pottery new and unrefined; often buried as a refining process. I believe the plants came originally from Peru." (*Husbands.*)

28641 and 28642. "Negra (black). It is from these grapes that the celebrated Elqui red wine is made."

28641. Seeds.**28642. Cuttings.****28643 and 28644.**

From the Andean Highlands near Cuzco, Peru. Presented by Mrs. Franklin Adams, Washington, D. C. Received August 10, 1910.

Seeds of the following:

28643. ZEA MAYS L.

Corn.

28644. CHENOPODIUM QUINOA Willd.

Quinoa.

See No. 28634 for previous introduction.

28645. VICIA FABA L.**Horse bean.**

From Paris, France. Purchased from Vilmorin, Andrieux & Co. Received August 12, 1910.

Winter.

28646. MEDICAGO SATIVA TUNETANA Murbeck.

From Oued Zenati, Algeria. Presented by Mr. A. Clavé. Received August 13 1910.

"The plants from which this seed was taken were found in a single, very limited place on calcareous and uncultivated ground. I had to watch carefully to save from the sheep, which are very fond of this excellent forage, a few flowering stems and a few seeds. It was impossible for me to get a larger quantity because of the great scarcity of this species in this region." (*Clavé.*)

Distribution.—Pine woods on both sandy and calcareous soil in the mountainous region of central Tunis and at Oued Zenati and Tebessa in the province of Constantine in Algeria.

28648 and 28649.

From Turkestan. Received through Mr. Frank N. Meyer, agricultural explorer, August 13, 1910.

28648. TULIPA sp.**Tulip.**

From mountains near Bachar-den, Turkestan. "(No. 790, June 5, 1910.) A tulip growing on sunburned mountain sides in decomposed rock soil. Flowers apparently red." (*Meyer.*)

28649. EREMURUS sp.

From near Kulikalan, in the province of Samarkand, Turkestan. "(No. 789.) A very robust, ornamental Eremurus, having spikes of flowers that grow 4 feet tall and are rosy pink in color. Found at an altitude of about 7,000 feet in rich, blackish soil. Of value as an ornamental plant in fairly dry climes; apparently able to stand low temperatures." (*Meyer.*)

28653. ERAGROSTIS LEHMANNIANA Nees.(?)

From Mowbray, Cape Colony, South Africa. Presented by C. Starke & Co. (Ltd.). Received August 13, 1910.

Distribution.—Central and eastern South Africa, extending from the Graaff Reynet region and Natal southward to the Cape.

Seeds.

28655. TRITICUM TURGIDUM L.**Wheat.**

From Valencia, Spain. Presented by Mr. Robert Frazier, jr., American consul. Received July 12, 1910.

"Irrigated wheat, the typical variety grown in this vicinity. Usually planted from the end of November to the middle of December." (*Frazier.*)

28656 and 28657. SOLANUM spp.

From Peru. Presented by Dr. A. Weberbauer, German Legation, Lima. Received August 16, 1910.

Tubers of the following; notes by Dr. Weberbauer:

28656 and 28657—Continued.**28656. SOLANUM sp.**

"Tubers of an undoubtedly wild *Solanum* that I collected myself. I found the plants on the hills near Lima, between crumbled rocks in the so-called Loma formation, 200 meters above sea level. The specimens were very young, in the beginning of their growing period, but one of them already had blooms. These were deep violet, almost the color of *Viola odorata*. The plants were very similar to the potato, but were not *Solanum tuberosum*, but the *Solanum maglia* which I collected (formerly) near Mollendo.

"Lima, considering its latitude, has very low temperatures; from June to October the average monthly temperature is 15.9° to 16.7° C.; sometimes the temperature sinks to 12° C. From November to May there is practically no precipitation. From June to October, however, it is cloudy almost continuously, and slight rains dampen the ground so that the previously bare hills are covered with a green carpet of plants (chiefly annual plants, such as tuberous and bulbous plants). This vegetation is called Loma."

28657. SOLANUM sp.

"Tubers of another *Solanum* species related to the potato. This, too, was found at 200 meters above sea level and between crumbled rocks in the Loma. The plant has pale-lilac blooms and is distinguished from *Solanum tuberosum*, among other things, by the narrow leaf lobes." (*Weberbauer*.)

28658. RUBUS sp.**Raspberry.**

From the top of Mount Omei, Szechwan Province, China. Presented by Dr. Edgar T. Shields, Yachow, Szechwan Province, China. Received July 23, 1910.

"Seed of a most delicious, large, yellow raspberry." (*Shields*.)

28659. VICIA FABA L.**Horse bean.**

From Yachow, Szechwan Province, China. Presented by Dr. Edgar T. Shields. Received July 23, 1910.

"These are very prolific and are used extensively in feeding horses and cows. They are also eaten by the poorer people, boiled and roasted in oil." (*Shields*.)

28660. MAGNOLIA CAMPBELLII Hook. f. and Thoms.

From Erfurt, Germany. Purchased from Haage & Schmidt. Received August 17, 1910.

A large deciduous-leaved tree, whose rosy flowers, often 10 inches in diameter, open before the leaves appear. The leaves are 12 inches long by 4 inches wide, smooth above and silky pubescent below.

Distribution.—In the forests on the slopes of the Himalayas, at an elevation of 8,000 to 10,000 feet, in Sikkim and Bhutan, northern India.

28661. ZEA MAYS L.**Corn.**

From Zomba, Nyasaland Protectorate, Africa. Presented by Mr. E. W. Davy, agriculturist, Agricultural and Forestry Department. Received August 13, 1910.

"Seed of a native-grown type of Nyasaland. I have carried out selection work on it for only one year at present, and it will take some years to get a very true and improved type fixed. The results of even the first year show a marked improvement, the yield being at the rate of 4,550 pounds of dried husked corn per acre. I would recommend you to test it in your Southern States with a good rainfall." (*Davy*.)

28662 and 28663.

From South Africa. Presented by Prof. J. Burt Davy, government agrostologist and botanist, Transvaal Department of Agriculture, Pretoria. Received August 1, 1910.

Seeds of the following:

28662. ACACIA LITAKUNENSIS Burchell.

"This was collected 70 miles southeast of the type locality. I have not been able to learn that the wood has any special economic value, but the tree is ornamental and stands considerable drought, with some frost." (Davy.)

Distribution.—The vicinity of Litakun in Bechuanaland, South Africa.

28663. LEBECKIA CUSPIDOSA (Burch.) Skeels.

(*Spartium cuspidosum* Burchell, Travels, vol. 1, p. 348, 1822.)

(*Genista cuspidosa* DC., Prodrumus, vol. 2, p. 147, 1825.)

(*Stiza psiloloba* E. Meyer, Commentariorum de Plantis Africae Australioris, p. 32, 1835.)

(*Lebeckia psiloloba* Walp., Linnæa, vol. 13, p. 478, 1839.)

This South African leguminous shrub is reported by Harvey (Flora Capensis, vol. 2, p. 84, 1861-62) from "Near Uitenhage," and it was originally described from between "Gattikamma" (white water) and "Klaarwater," now known as Griquatown, and apparently near the latter locality. Burchell says in regard to it: "In one part, toward the end of our journey, we passed abundance of a handsome shrub, from 5 to 7 feet in height, covered with showy yellow flowers, but quite destitute of leaves, and even by this light easily to be distinguished as a plant which had not been anywhere seen before. It was completely armed at all points, its green leafless branches being terminated by a spine as sharp as a needle."

De Candolle in the Prodrumus restricted the use of the generic name *Spartium* to a single species of the Mediterranean region, *S. junceum*, and referred this South African plant to *Genista*. The species was apparently again described by E. Meyer under the name *Stiza psiloloba*, and since *Stiza* is not recognized as distinct from the earlier *Lebeckia*, Meyer's plant was placed in that genus by Walpers. The original specific name published by Burchell, though long in disuse, is here restored.

"This is a nearly leafless, dense shrub, about 6 feet high, bearing ornamental yellow flowers. It is very spiny and should be suitable for hedges. It comes from the Kalahari, near Kuruman, and is likely to suit dry, warm regions." (Davy.)

28665. SOLANUM TUBEROSUM L.**Potato.**

From Temuco, Chile. Presented by Mr. D. S. Bullock. Received August 19, 1910.

"*Damma*. An early variety." (Bullock.)

Tubers.

28667 to 28672.

From Mauritius. Presented by Mr. Gabriel Regnard. Received July 29, 1910.

Seeds of the following:

28667. APHLOIA THEAEFORMIS (Vahl) Bennett.

"*Bois Goyave* or *Bois Viliu*. A glabrous, much-branched shrub; leaves oblong, obtuse, or acute, entire or toothed, 1 to 4 inches long. Flowers yellowish. Fruit ovoid-ampullæform $\frac{1}{2}$ to $\frac{3}{4}$ inch long; 10 to 12 seeded." (Regnard.)

28667 to 28672—Continued.

Distribution.—Frequent in the woods on the islands of Mauritius, the Seychelles, Rodriguez, and Madagascar.

28668. *ELAEOCARPUS* sp.

28669. *EBRETIA ACUMINATA* R. Br.

"An Indian tree of the boraginaceous family yielding a tough, light, and durable wood. It bears bunches of tiny white flowers and red seeds the size of a small pea. Is a very showy and ornamental tree." (*Regnard.*)

Distribution.—Slopes of the subtropical Himalayas and the adjacent plains from Gurhwal to Bhutan in India, and in Java, Australia, and Japan.

28670. *MIMUSOPS IMBRICARIA* Willd.

"A large tree with gray, glabrous branches. Leaves oblong, glabrous, shining. Fruit a drupe, globose, the size of a small apple, one to four seeded." (*Regnard.*)

Distribution.—Thick woods in the interior of the islands of Mauritius and Reunion.

28671. *TAMBOURISSA AMPLIFOLIA* (Tul.) DC.

"Branchlets stout. Leaves alternate, oblong, $\frac{1}{2}$ to 1 foot long. Bud of female perianth black, apiculate, $1\frac{1}{2}$ inches thick, globose, with conical fruits $\frac{1}{2}$ inch long." (*Regnard.*)

Distribution.—In the forests on the slopes of the Pouce and other mountain ranges on the island of Mauritius.

28672. (Undetermined.)

"A forest shrub (?)." (*Regnard.*)

28673 to 28675.

Plants of the following, turned over to the Department for distribution by Dr. J. N. Rose, associate curator, Division of Plants, United States National Museum, Washington, D. C., August, 1910.

28673. *ECHEVERIA HOVEYI* ROSE *n. sp.*

"Usually stemless, but when old developing a short stem; leaves forming a loose spreading rosette, pale green with broad pinkish or white margins and these more or less wavy or sometimes colored throughout; flowering stem a second raceme bearing 6 to 12 flowers; corolla pinkish.

"The origin of this form is unknown. It is probably some horticultural sport or hybrid, but does not closely resemble any of our common cultivated forms, although it may be said to belong to the group of species in which *Echeveria secunda* and *Echeveria glauca* are found." (*Rose.*)

28674. *PARMENTIERA CEREIFERA* Seem.

Candle tree.

"This is one of the most remarkable trees of the Tropics, a native of Panama. It grows 30 to 40 feet high and produces from its stem and old branches a profusion of almost sessile campanulate flowers; these are followed by yellowish cylindrical, smooth points, 12 to 18 inches long, which appear exactly like wax candles, as the botanical name implies. So close is the resemblance that travelers, seeing the tree in fruit for the first time, are liable to be temporarily puzzled as to whether the candles of shops are made in factories or grow on trees. The candlelike fruits are suspended from the bare stem and branches by short slender stalks; dangling in the air, they readily give the impression of a chandler's shop. This impression is intensified as night falls and the numerous fireflies move among the fruits. It is not, perhaps, surprising that the inex-

28673 to 28675—Continued.

perienced traveler should not infrequently be informed that the fireflies perform the duty of lighting up these 'candles' when required by the denizens of the jungle. The fruits are fleshy and juicy and have a peculiar applelike odor. They are eaten by certain tribes, and also by cattle. The tree belongs to the natural order Bignoniaceæ." (Rose.)

28675. ZINZIBER sp.

Wild ginger.

"From near Tampico, Mexico. Sent in by Dr. Edward Palmer." (Rose.)

28676 and 28677. MANGIFERA INDICA L.

Mango.

From San Jose, Costa Rica. Presented by Mr. A. R. Guell, Louisiana State University, Baton Rouge, La. Received August 22, 1910.

Cuttings of the following:

28676. "Our common fiberless variety." (Guell.)

28679 to 28683.

From Richmond, New South Wales, Australia. Presented by Mr. H. W. Potts, principal, Hawkesbury Agricultural College. Received August 2, 1910.

Seeds of the following:

28679. ANDROPOGON PERTUSUS (L.) Willd.

Distribution.—Southern Europe and Asia, extending from Sicily to India, in tropical Africa, and in Queensland and New South Wales in Australia.

28680. ANDROPOGON REFRACTUS R. Brown.

Distribution.—Eastern Australia, at Port Essington in North Australia, along the Brisbane River in Queensland, at Port Jackson in New South Wales, and at Mitta-Mitta in Victoria.

28681. DICHELACHNE CRINITA (L. f.) Hook. f.

Distribution.—Throughout Australia and in Tasmania and New Zealand.

28682. EUCALYPTUS ROBUSTA Smith.

Swamp mahogany.

Distribution.—New South Wales in Australia, extending from Port Jackson to the Blue Mountains.

28683. STERCULIA DIVERSIFOLIA G. Don.

Kurrajong tree.

Distribution.—Australia, in the provinces of Queensland, New South Wales, Victoria, and Western Australia.

28684. DIOSPYROS MONTANA CORDIFOLIA (Roxb.) Hiern.

From Lahore, Punjab, India. Presented by Mr. W. R. Mustoe, superintendent of the Government Gardens. Received August 23, 1910.

A tree with short spines occasionally on the trunk and older branches; young branches and leaves softly pubescent; leaves narrowly ovate, slightly heart shaped at the base; fruit globular and about the size of a large cherry. The wood is yellowish gray and soft, but durable. It is used for making carts and tools and would be suitable for furniture.

Distribution.—India, from the Himalayas to Ceylon and Tenasserim, through the Malay Archipelago to tropical Australia.

28685. PRUNUS MUME Sieb. and Zucc. Japanese apricot.

From Yokohama, Japan. Purchased from the Yokohama Nursery Co. Received August 24, 1910.

See Nos. 9211 to 9216 for description.

28686 and 28687.

From Washington, D. C. Presented by Mr. W. R. Smith, superintendent, National Botanic Garden. Numbered for convenience in recording distribution August 25, 1910.

Plants of the following:

28686. ACTINIDIA KOLOMIKTA (Maxim.) Rupr.

See Nos. 20360 and 22593 for description.

28687. PASSIFLORA CAPSULARIS L.

"A climbing vine with leaves dividing below the middle into two oblong lanceolate lobes; flowers greenish white, the filament crown pale yellowish green surrounding a double white cup, anthers and stigmas yellow. Fruit about 2 inches long, oblong, and six-angled." (*Adapted from Botanical Magazine, vol. 55, pl. 2868.*)

Distribution.—Mirador in southern Mexico and southward to Ecuador and Brazil.

28688 and 28689.

From Paraguay, South America. Presented by Mr. C. F. Mead, Piropo, Faraguay. Received August 20, 1910.

Seeds of the following:

28688. PSIDIUM GUAJAVA L.

Guava.

"In Spanish called '*Guayaba grande*' and in Guarany '*araza-guaza*.' It is the same class of fruit as the small guayaba, except that it is much larger, about the size of a hen's egg, and is borne on a tree which in five years attains a height of 20 to 25 feet and a diameter of 8 to 10 inches. The wood of this tree is hard, tough, and impossible to split." (*Mead.*)

28689. BROMELIA sp.

"Caraguata."

"This plant in Guarany is called '*caraguata*'. It grows in 'camp hereabouts especially in barren spots. Every year in the fall the center leaves turn bright red and it bears a cluster of pink and white flowers, similar to tube-roses. The fruits, which are used here for preserves only, are borne in a cluster 10 to 15 inches long and 4 to 6 inches in diameter; they are the size of a small plum and are bright yellow when ripe. The plant has a bad name, owing to the difficulty of exterminating it when it is well started."

(*Mead.*)

28690. WIDDRINGTONIA WHYTEI Rendle. Mlanje cypress.

From Zomba, Nyasaland Protectorate, Africa. Presented by Mr. J. M. Purves, chief forest officer. Received August 25, 1910.

"The seed germinates quickly, usually in three or four weeks, in moist and slightly shaded soil, with a mean temperature of from 65° to 70° F. The tree occurs in about 17° south latitude at elevations of from 5,000 to 6,000 feet. Above the latter it becomes very stunted in growth. It exhibits a preference for deep gullies and ravines, and seems to detest very strong winds. The soil varies considerably, and fine trees often occur in the crevices of the decomposing granite rocks, of which the mountain chiefly consists. The rainfall will vary from 70 to 90 inches, and in the dry months the

28690—Continued.

forests are subject to heavy mist and fog, with the result that the undergrowth never dies and is always very moist. The rains fall in the hot months, October to April, and herein will lie your chief difficulty in establishing the tree in the Northern Hemisphere. In the south of England it is grown with difficulty, as it makes its new growth in the same months as at Mlanje, with the result that it does not ripen off before the advent of frosts. At elevations of 3,000 feet in Nyasaland, where the conditions of climate are more xerophytic, it makes a nice ornamental tree, but it begins to die out suddenly after 10 or 12 years. It seems to thrive best in its native habitat when it is slightly intermixed with other leaf-shedding trees and evergreens, typical of mountain forests, as the decaying foliage, etc., helps to form a better layer of humus." (*E. W. Davy, acting chief forest officer, Agricultural and Forestry Department, Zomba, Nyasaland Protectorate, Africa.*)

28691 to 28703. MANGIFERA INDICA L.**Mango.**

From Seharunpur, India. Purchased from Mr. A. C. Hartless, superintendent, Government Botanic Gardens. Received August 23, 1910.

Seeds of the following:

- | | |
|---------------------------------|--|
| 28691. <i>Sanduria.</i> | 28698. <i>Sharbati</i> (brown). |
| 28692. <i>Singapuri.</i> | 28699. <i>Bulbulchasm.</i> |
| 28693. <i>Gopalbhog.</i> | 28700. <i>Calcutta Amin.</i> |
| 28694. <i>Ennurea.</i> | 28701. <i>Hathijhul.</i> |
| 28695. <i>Faizan.</i> | 28702. <i>Chickna.</i> |
| 28696. <i>Tamancha.</i> | 28703. <i>Faquirmala.</i> |
| 28697. <i>Sunahra.</i> | |

28704. ROLLINIA sp.

From Port Louis, Mauritius. Presented by Mr. G. Regnard. Received August 26, 1910.

"Tree 30 feet; leaves 7 inches long; fruit heart shaped, with prominent eyes of a yellowish color when ripe; edible." (*Regnard.*)

28705 to 28707. SOLANUM spp.**Wild potato.**

From Marseille, France. Presented by Prof. Edouard Heckel, director, Botanic Gardens. Received August 29, 1910.

Tubers of the following:

- 28705 and 28706.** *SOLANUM MAGLIA* Schlecht.
28705. White and violet. **28706.** Fifth generation.
28707. *SOLANUM COMMERSONII* Dun.
 Half wild.

28708 to 28710.**Willow.**

From Limavida, via Molina, Chile. Presented by Mr. José D. Husbands. Received August 30, 1910.

Cuttings of the following:

- 28708.** *SALIX VITELLINA* L.

"(H. No. 609.) *Yellow Mimbre.* An industrial plant of value, introduced into Chile from Europe by the Spaniards. Grows in waste spots along the edge of canals, creeks, ravines, etc. It is used to make extra strong baskets for holding fruit, potatoes, or corn and for general farm and factory uses; also to tie the fences, thatches, etc." (*Husbands.*)

28708 to 28710—Continued.**28709. SALIX HUMBOLDTIANA Willd.**

"(H. No. 611.) *Sauce*. A Chilean willow that grows wild, principally in the sands of the river-bottom lands. Its greatest use is for live fence posts in wet or water-covered lands. Cuttings when planted take root quickly and grow very rapidly. Its form varies and it is not a uniform growth like 'castilla' or the weeping varieties. The bark is used in medicine as an astringent, febrifuge, etc., and is a valuable remedy; it also gives a white crystallized substance called 'salicina,' used in fevers as quinine." (*Husbands*.)

28710. SALIX HUMBOLDTIANA Willd.

"(H. No. 610.) Variety *fastigiata*. The Chilean castilla. These trees grow perfectly straight and attain a great height. All the branches grow up close to the trunk, like a well-trimmed Populus. I have seen these trees growing in the worst arid clays, perfectly dry." (*Husbands*.)

28711. GOSSYPIUM sp.**Cotton.**

From Manly, near Brisbane, Queensland, Australia. Presented by Mr. Daniel Jones. Received August 30, 1910.

"Seed of a hybrid, naturally crossed, found in a field; it is of good quality and a good bearer. So far we are not sure whether it will maintain its present standard, but we are experimenting with it. This sample is from a 3-year-old shrub. We hope to fix a type by breeding. Frequently 1 to 2 pounds of cotton are obtained from a shrub of this variety, and in one instance a 2-year-old plant gave us 4 pounds; this is abnormal, however. Mascote (tree cotton) types frequently give up to 6 pounds per shrub." (*Jones*.)

28712. MORAEA BICOLOR (Lindl.) Steud.

From Glasnevin, Dublin, Ireland. Presented by Mr. F. W. Moore, M. A., director, Royal Botanic Gardens. Received August 29, 1910.

"A South African flowering bulb having a flower 2 inches across, yellow, with beautiful brown spots on the outer segments; style crests yellow." (*Extract from Bailey, Cyclopaedia of American Horticulture.*)

Distribution.—The coast region of Cape Colony between the Olifant's and Kei rivers.

28713. BERBERIS FREMONTII Torrey.**Barberry.**

From Tucson, Ariz. Presented by Mr. J. J. Thornber, botanist, University of Arizona. Received August 29, 1910.

"Native barberry from northern Arizona. A very drought-resistant species, and promising as an ornamental." (*Thornber*.)

See No. 12242 for previous introduction.

Distribution.—Slopes of canyons in western Texas, New Mexico, Arizona, and southern California.

28714. ANONA CHERIMOLA Miller.**Cherimoya.**

From Lima, Peru. Presented by the director of the National School of Agriculture and Veterinary Surgery, through Mr. Edw. J. Habick. Received through Rev. V. M. McCombs, Callao, Peru, August 30, 1910.

28715 to 28730.

From Durban, Natal, South Africa. Presented by Prof. J. Medley Wood, director, Botanic Gardens. Received July 25, 1910.

Seeds of the following trees and evergreen shrubs:

28715. ASSONIA SPECTABILIS (Bojer) Kuntze.

Distribution.—In the Mozambique district of East Africa, and in Madagascar and Mauritius.

28716. BAUHINIA GALPINI N. E. Brown.

Distribution.—Along the coast of southeastern Africa, in the Makua district of Mozambique, and in the vicinity of Barberton in the Transvaal.

28717. BAUHINIA PETERSIANA Bolle.

Distribution.—The vicinity of Senna in Zambesiland, at the foot of Mount Moramballa and in the Manganya Hills in the Mozambique district of tropical Africa.

28718. BAUHINIA PICTA (H. B. K.) DC.

Distribution.—The valley of the Magdalena River, in the northern part of Bolivia.

28719. BOSCIA UNDULATA Thunb.

Distribution.—In the primitive woods in the vicinity of Uitenhage and district of George in Cape Colony; also in the island of Mauritius.

28720. BRUNSFELSIA AMERICANA L.

28721. CALPURNIA AUREA (Lam.) Benth.

Distribution.—In Abyssinia, the highlands of Huilla and Golungo Alto in Lower Guinea, and in the vicinity of Durban in Natal.

28722. CARISSA GRANDIFLORA (E. Mey.) DC.

See Nos. 11734 and 13239 for previous introductions.

28723. DOYALIS CAFFRA (Hook. and Harv.) Warb.

Distribution.—The eastern districts of Cape Colony and in Kafirland, South Africa.

See No. 3724 for description.

28724. DRACAENA RUMPHII (Hook.) Regel.

Distribution.—In woods along the eastern coast of Cape Colony, from near Uitenhage northward to Pondoland.

28725. INDIGOFERA sp.

28726. MIMOSA RUBICAULIS Lam.

Distribution.—Afghanistan and India, rising to an elevation of 5,000 feet in the western Himalayas.

28727. MORAEA IRIDIODES L.

See No. 13732 for previous introduction.

Distribution.—Tropical and South Africa, extending from the valley of the River Umba in German East Africa and from British Central Africa southward to Cape Colony.

28728. TECOMA BERTEROI DC.

Distribution.—On the island of Haiti in the West Indies.

28715 to 28730—Continued.**28729. OPHIOBOSTRYX VOLUBILIS (Harvey) Skeels.**

(*Bowiea volubilis* Harvey; Hooker, Botanical Magazine, vol. 93, pl. 5619, 1867.)

The original generic name given this curious liliaceous plant is invalid since it had been used by Haworth 43 years earlier (Philosophical Magazine, vol. 64, p. 299, 1824) for another proposed genus belonging to the same family. No other name has been applied to the later genus *Bowiea*, and *Ophiobostryx* is therefore proposed, in allusion to the leafless asparaguslike branches suggesting snaky locks, such as supplanted hair on the head of the monster Medusa, according to classical mythology. The genus has only one species, *O. volubilis*.

Ophiobostryx volubilis was first sent to the Royal Gardens, Kew, by Henry Hutto, of Grahamstown, South Africa, and has since been found at Katberg in the Stockenström division of the coast region, in the Orange River Colony and Transvaal, in the Kalahari region, and near Transkei, Kokstad, and Durban, in the eastern part of Cape Colony.

28730. MONDIA WHITEII (Hook. f.) Skeels.

(*Chlorocodon whiteii* Hook. f., Botanical Magazine, pl. 5898, 1871.)

The generic name *Chlorocodon*, "in allusion to the bell-like green flowers," was applied to this plant in 1871 by Sir Joseph Hooker (Botanical Magazine, vol. 97, pl. 5898), who was doubtless unaware that the name had been used by Fourreau in 1869 (Annales de la Société Linnéenne de Lyon, n. s., vol. 17, p. 113) for a proposed genus of ericaceous plants. No other name appears to have been used for the later genus known as *Chlorocodon*, and since a new name is necessitated *Mondia* is proposed, this being an adaptation of the native name "Mondi," or "Mundi," applied to this plant.

Mondia whiteii was originally described from Fundisweni, Natal, but has since been collected at Yaunde in Kamerun; Bumbo, Pungo Ndongo, and other places in Angola; also at Karagwe and Bukoba in German East Africa, and in Nyasaland.

28731 and 28732. SOLANUM MAGLIA Schlecht. Wild potato.

From Marseille, France. Presented by Dr. Edouard Heckel, director, Botanic Garden. Received September 1, 1910.

28731. Fourth generation, violet.

28732. Fourth generation, violet.

Distribution.—See No. 28705.

28733 to 28738.

From Fort Hall, Nairobi, British East Africa. Presented by Mr. J. McClellan, Provincial Commission. Received July 29, 1910.

Seeds of the following:

28733. ANDROPOGON SORGHUM (L.) Brot.

Sorghum.

"This lot represents a mixture of two of the East African sorghum types, probably durras, one with white seeds and one with red. Such mixtures are commonly received from central East Africa and from Abyssinia, but the varieties have always proved too late to mature in this country." (*Carleton R. Ball.*)

28734. CAJAN INDICUM Spreng.

28733 to 28738—Continued.

- | | |
|---|----------------|
| 28735. CHAETOCHLOA ITALICA (L.) Scribn. | |
| 28736. DOLICHOS LABLAB L. | Bonavist bean. |
| 28737. ELEUSINE CORACANA (L.) Gaertn. | Ragi millet. |
| 28738. PENNISETUM AMERICANUM (L.) Schum. | Pearl millet. |

28739. CERATONIA SILIQUA L.**Carob.**

From the estate of the Comte de Puerto Hormosa, at Pizarra, near Malaga, Spain.
Received through Mr. R. S. Woglum, September 6, 1910.

"These cuttings were taken from the best carob tree I saw in Spain. A magnificent tree, fully 30 feet high and noted for being very prolific in fruit." (Woglum.)

28740 to 28744.

From Mauritius. Presented by Mr. G. Regnard, Port Louis. Received September 2, 1910.

Seeds of the following; quoted notes by Mr. Regnard:

- 28740.** PECTINEA PAUCIFLORA (Thouars) Skeels.
(*Erythrospermum pauciflorum* Thouars, Veg. Iles Austr. Afr., p. 67, pl. 21, fig. 1, 1806.)
(*Erythrospermum mauritianum* Baker, Flora of Mauritius and Seychelles, p. 10, 1877.)

The genus *Pectinea* was published by Gaertner in 1791 (*De Fructibus et Seminibus Plantarum*, vol. 2, p. 136, pl. 111, fig. 3), with *P. zeylanica* as the only species, while the name *Erythrospermum*, often applied to this genus, appears to have been used no earlier than 1792 or 1793 on a plate published by Lamarck (*Encyclopédie Méthodique*, pl. 274). No description accompanied this plate and the text explaining it was not published until even a later date. The first publication of a description of the genus under the name *Erythrospermum* appears to have been effected in 1806 by Thouars (*Histoire des Végétaux Recueillis dans les Isles Australes d'Afrique*, p. 65), who states that Lamarck's figure only had appeared. There is apparently no reason, therefore, why Post and Kuntze, *Lexicon Generum Phanerogamarum*, should not be followed in the restoration of Gaertner's name, *Pectinea*, published 15 years earlier than *Erythrospermum*.

Pectinea pauciflora was originally described by Thouars from Mauritius and is still unknown elsewhere in an indigenous state.

"*Bois Manioc* or *Bois Cochon*. Small tree. Fruit globose, hard, $\frac{1}{4}$ to 1 inch thick. Found in mountain woods in Mauritius."

28741. EUGENIA GLOMERATA Lam.

"*Bois de Pomme*. Berry as large as a pea. Frequent in mountain woods in Mauritius; also in Madagascar."

28742. (Undetermined.)

"*Bois Maigre*. *Bois sans écorce*. *Bois Bigaigon*. Berry $\frac{1}{4}$ inch long. Found in Mauritius in dense woods; also in Reunion."

28743. MERIANA sp.?

"From Pouce Mountain, Mauritius. Pink color."

28744. VOANDZEA SUBTERRANEA (L.) Thouars.**Woandsu.**

"Bambara ground nuts. Nuts are eaten boiled and are very rich and nourishing. From Africa."

See No. 23453 for further description.

28745. PRUNUS sp.**"Plumcot."**

From Harput, Turkey. Presented by Mr. William W. Masterson, American consul. Received August 26, 1910.

"An unusually fine-tasting fruit that might be called a 'plumcot.' It was about the size of a greengage plum, of a light-yellow color, and had a decided apricot flavor, indicating that it was a hybrid between the plum and the apricot." (*Masterson.*)

28746. SOLANUM COMMERSONII Dun.**Wild potato.**

From Montevideo, Uruguay. Presented by Mr. Fred W. Goding, American consul. Received September 6, 1910.

Tubers.

28747. SOLANUM sp.**Wild potato.**

From Asuncion, Paraguay. Presented by Mr. T. R. Gwynn. Received September 6, 1910.

"The wild potato is here in profusion. The plant and leaf are almost exactly like the cultivated varieties, but the roots are very different. It puts forth a long underground stem to the end of which the potatoes are attached. These are sometimes as large as a walnut, hull and all, though generally much smaller." (*Gwynn.*)

28748 to 28751. MANGIFERA INDICA L.**Mango.**

From Poona, Bombay, India. Purchased from the Empress Botanical Gardens. Received August 31, 1910.

Seeds of the following:

28748. *Badsha.***28750.** *Gudbeli.***28749.** *Fernandez.***28751.** *P'ote (?)*.**28752 to 28760. MANGIFERA INDICA L.****Mango.**

From Seharunpur, India. Purchased from the Government Botanic Gardens. Received August 31, 1910.

Seeds of the following:

28752. *Gola.***28757.** *Fajri* (long).**28753.** *Khaparia.***28758.** *Lamba Bhadra.***28754.** *Langra.***28759.** *Malda.***28755.** *Bombay* (green).**28760.** *Najibabadi.***28756.** *Fajri* (round).**28761 and 28762.**

From Palestine. Purchased from Mr. Aaron Aaronsohn, director, Jewish Agricultural Experiment Station, Haifa, Palestine. Received August 22, 1910.

Seeds of the following:

28761. *VICIA ERVILIA* (L.) Willd.**Bitter vetch.****28762.** *LATHYRUS SATIVUS* L.

"I think that *Lathyrus sativus* will make a quicker growth in the California orange orchards than *Vicia ervilia*, and for this reason I believe it will be better adapted as a green manure. Furthermore, I believe it will make a heavier growth and give a bigger yield than *Vicia ervilia*; at least, this is its behavior in Palestine, where I have had experience with both species. In my opinion *Lathyrus sativus* is in no way inferior to the fenugreek, which has been used so successfully in the orange orchards in Cali-

28761 and 28762—Continued.

fornia. There might be a possible advantage in trying *L. sativus* in place of fenugreek, inasmuch as the seed is cheaper." (*Aaronsohn.*)

28763. ANONA MONTANA MacFayden.

From Mayaguez, Porto Rico. Presented by Mr. W. E. Hess, assistant horticulturist, Agricultural Experiment Station, through Mr. P. J. Wester. Received August 23, 1910.

"A small tree indigenous to the West Indies; the fruit is subglobose, muricate, and the flesh dry and unedible.

"Introduced for trial as a stock for the cultivated anonas." (*Wester.*)

28764. ZIZIPHUS JUJUBA Miller.

From Las Cruces, N. Mex. Presented by Mr. David Griffiths. Received September 8, 1910.

"The trees from which these seeds were obtained were loaded with fruit. There are only two alive; one is 12 feet high. The trees are probably about 12 to 15 years old, but have had very poor conditions and are badly crowded." (*Griffiths.*)

28765. PHASEOLUS MAX L.

From Port of Spain, Trinidad. Presented by the assistant secretary of the Board of Agriculture at the request of Mr. R. B. Dickson. Received August 23, 1910.

28766. HELYGIA PADDISONI (Baker) Skeels.

(*Parsonsia paddisoni* R. T. Baker, Proc. Linn. Soc. N. S. Wales, vol. 24, p. 385, 1899.)

The original use of the generic name *Parsonsia* was by Patrick Brown in 1756 (*Natural History of Jamaica*, p. 199, pl. 21, fig. 2), for a species later published by Linnæus as *Lythrum parsonsia*, a plant of the family Lythraceæ. The genus *Parsonsia* as proposed by Brown was recognized in 1763 by Adanson (*Familles des Plantes*, vol. 2, p. 234), whose description and citation completed the technical publication of the name. *Parsonsia* is therefore the valid name for *Cuphea*, the genus to which *Lythrum parsonsia* was later referred. This original use of *Parsonsia* by Patrick Brown and Adanson invalidates its use by Robert Brown in 1809 (*Memoirs Wernerian Natural History Society*, vol. 1, p. 64) for the apocynaceous genus to which the species given above belongs. Several other generic names have been proposed for various species of this genus, and the earliest of them, *Helygia*, published by Blume in 1826 (*Bijdragen tot de flora van Nederlandsch Indië*, vol. 2, p. 1043) with *H. javanica* as the type, is recognized as the valid name for the group, and the species under consideration is accordingly transferred to it.

Helygia paddisoni was originally described from New Angledool, New South Wales, and is not known to occur elsewhere.

From Sydney, New South Wales, Australia. Presented by the curator, Department of Public Instruction, Technical Education Branch, Technological Museum. Received August 30, 1910.

"A glabrous woody climber. Leaves opposite, glabrous on both sides. The stem is about 1 inch in diameter a foot or so above the ground, the bark being of a quite corky nature.

"Stock are very fond of the leaves, so that this plant should be ranked as a fodder. My attention was first drawn to this plant by Mr. A. Paddison, of New Angledool, who

28766—Continued.

sent for identification a large tuber or 'yam' weighing about 10 pounds, stating that similar 'yams' were eaten both by settlers and aborigines. The interior is composed of a whitish substance, the chemical analysis of which shows only 4½ per cent of carbonaceous principles. It tastes very much like a turnip, both in the raw and cooked condition. The color and consistency of the largest specimens resemble those of the common mangel-wurzel." (*R. T. Baker.*)

"A vine generally found growing at the foot of and twisting itself around some small tree, and that tree in nine cases out of ten a 'wilgá' (*Geijera parviflora* Lindl.). The top 'yam' of the plant we dug was 4 inches from the surface, and the deepest that we could find was 21 inches from the surface. We dug up all that we could find, carried them home, and weighed each one separately, 29 'yams' in all. The total weight was 101½ pounds; the heaviest one weighed 12½ pounds." (*A. Paddison.*)

28767 and 28768. MELINIS MINUTIFLORA Beauv. Molasses grass.

From Sao Paulo, Brazil. Purchased from Mr. H. M. Lane, Mackenzie College.
Received September 3, 1910.

Seeds of the following:

28767. "*Negro Head.*"

28768. Ordinary variety.

See Nos. 23201 and 23381 for previous introductions.

28770. SOLANUM JAMESII Torr.

Wild potato.

Collected in the Chiricahua National Forest. Presented by Mr. Arthur H. Zachau, forest supervisor, Portal, Ariz., through the Forest Service. Received September 15, 1910.

28771. SOLANUM sp.

Wild potato.

From Zacatecas, Mexico. Collected by Mr. F. E. Lloyd. Presented by Dr. J. N. Rose, associate curator, United States National Museum, Washington, D. C. Received September 10, 1910.

(Rose No. 08.219.)

28772 to 28779.

From Chile. Received through Mr. José D. Husbands, Limavida, via Molina, Chile, September 2, 1910.

Seeds of the following; notes by Mr. Husbands:

28772. *GEUINA AVELLANA* Molina.

"(H. No. 595.) *Avellano.* These are fresh seed from the South and therefore harder than those sent heretofore from central Chile (S. P. I. No. 25611)."

28773. *DRIMYS WINTERI* Forster.

"(H. No. 599.) *Canelo del Sur.*"

Distribution.—Damp slopes of the exposed valleys in the vicinity of the Strait of Magellan in southern Chile.

28774. *GERANIUM ROBERTIANUM* L.

"(H. No. 601.) *Alfilerillo* single."

28775. *ERODIUM* sp.

"(H. No. 602.) *Alfilerillo* double."

28776. *ARISTOTELLA MACQUI* L'Herit.

"(H. No. 603.) White maqui."

See No. 26306 for previous introduction.

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28772 to 28779—Continued.**28777.** (Undetermined.)

“(H. No. 605.) A beautiful evergreen lumber tree; name unknown to me.”

28778. *MELICA VIOLACEA* Cav.

“(H. No. 606.) A wild grass from the south of Chile. Is eaten by animals.”

Distribution.—The vicinity of Talcahuano on the coast of central Chile.**28779.** *SANGUIBORBA MINOR* Scop.

“(H. No. 607.) A wild grass from the south of Chile. Is eaten by animals.”

See No. 25040 for previous introduction.

28780. DIOSCOREA sp.

From Paraguay. Presented by Mr. C. F. Mead, Piropo. Received September 17, 1910.

“This will stand the same amount of frost as tomato vines. The tubers above ground are very similar to potatoes, but the color is dark, from yellow to red. There are also white tubers below the ground, the same as regular potatoes, but these are very small. It may be possible by selection or crossing to induce the plant to bear marketable potatoes, both below and above ground. It is not as heavy a cropper as the regular potato, and the necessity for a trellis upon which it can climb makes its economic value doubtful. It should be planted in the same manner as the potato. Will probably thrive in regions favored by sugar cane and oranges.” (*Mead.*)

28781. MELOCANNA BACCIFERA (Roxb.) Skeels. Multi bamboo.(*Bambusa baccifera* Roxb., Pl. Corom., vol. 3, p. 37, pl. 243, 1819.)(*Melocanna bambusoides* Trin., in Spreng., Neue Entdeckungen im Ganzen Umfang der Pflanzenkunde, vol. 2, p. 43, 1821.)

The genus *Melocanna* was established by Trinius in 1821 (Spreng., Neue Entdeckungen im Ganzen Umfang der Pflanzenkunde, vol. 2, p. 43), based on the single species *Bambusa baccifera* Roxburgh. Unfortunately the original specific name was changed and in consequence the species has since been known as *Melocanna bambusoides* Trin. The earlier specific name of Roxburgh is here restored.

The species was described by Roxburgh from the Chittagong Mountains in the southwestern part of Upper Burma, India, where it was called “Payu-tullu,” and it is now known to occur on the Khasi and Garrow Hills in Assam, and in Arakan and Tenasserim, in India.

From Sibpur, Calcutta, India. Presented by Maj. A. T. Gage, superintendent, Royal Botanic Gardens. Received September 19, 1910.

See No. 21347 for description.

28782. SECALE CEREALE L.**Rye.**

From Schlanstedt, Saxony, Germany. Purchased from Mr. W. Rimpau. Received September 19, 1910.

“Old-breeding.”

28783. ARGANIA SPINOSA (L.) Skeels.**Argan.**(*Sideroxylon spinosum* L., Sp. Pl., vol. 1, p. 193, 1753.)(*Argania sideroxylum* Roem. and Schult., Syst., vol. 4, p. 502, 1819.)

The genus *Argania* was established by Roemer and Schultes in 1819 (Linn. Systema Vegetabilium Secundum Classes, Ordines, Genera, Species, vol. 4, p. 502) and contained the single species *Sideroxylon spinosum* L., but in transferring the species to

28783—Continued.

the new genus the specific name was changed and the species has since usually been known as *Argania sideroxylum* Roem. and Schult. The original specific name is here restored in accordance with the now nearly universal custom.

The name *Sideroxylon spinosum* as used by Linnæus in the Species Plantarum appears to have included two distinct plants, the one under consideration here and that usually recognized as the type, being the one represented by the Plukenet synonym, but not the Malabar plant referred to by the Rheede citation. The species seems to have been originally described by Linnæus in his Hortus Cliffortianus from a garden plant, and he is in error in ascribing India as its habitat. The species is known in an indigenous state only in Morocco.

From Tangier, Morocco. Procured by Mr. R. L. Sprague, American consul, Gibraltar, Spain. Received September 17, 1910.

See No. 3490 for description.

28784. CORCHORUS CAPSULARIS L.**Jute.**

From Shanghai, China. Presented by Mr. Nicholas Tsu. Received September 17, 1910.

See No. 1963 for description.

28785. PIRATINERA UTILIS (H. B. K.) W. F. Wight. Palo-de-vaca.

The "cow tree of South America" was first named *Galactodendrum utile* by Humboldt, Bonpland, and Kunth (Nova Genera et Species, vol. 7, p. 163) in 1825. In 1830 David Don (Sweet, Hortus Britannicus, ed. 2, p. 462) placed the species in the genus *Brosimum*, giving it the name *B. galactodendron*, which in 1880 was corrected by Karsten (Deutsche Flora, p. 498) to *Brosimum utile*. The generic name *Brosimum* was published by Swartz (Nova Genera et Species Plantarum, p. 12) in 1788, with two species, *B. alicastrum* and *B. spurium*. In 1775, however, Aublet (Plantes de la Guiane Française, vol. 2, p. 888, pl. 340, fig. 1) published the genus *Piratinera* with one species, *P. guianensis*, which is considered to be congeneric with *Brosimum alicastrum* Swartz. The change of name from *Brosimum galactodendron* to *Piratinera utilis* was made by Mr. W. F. Wight in the Century Dictionary and Cyclopedia (vol. 12, p. 934, 1909) under "palo," subhead "palo-de-vaca."

From Caracas, Venezuela. Presented by Mr. Antonio Valero Lara. Received September 20, 1910.

"This tree grows here in the wooded mountains and highlands as well as along the seacoast." (Lara.)

28786 and 28787. CITRUS spp.

From Buitenzorg, Java. Presented by the director, Department of Agriculture. Received September 22, 1910.

Seeds of the following:

28786. CITRUS AURANTIUM L.

Variety *macrocarpa*.

28787. CITRUS MACRACANTHA Hassk.**28786 to 28793.**

From Beirut, Turkey. Presented by Mr. Alfred E. Day, through Miss Lanice B. Paton, Hartford, Conn. Received September 20, 1910.

28788 to 28793—Continued.

Seeds of the following:

28788. *MEDICAGO HISPIDA DENTICULATA* (Willd.) Urb. **Bur clover.**
 28789. *MEDICAGO ORBICULARIS* (L.) All.
 28790. *MEDICAGO* sp.
 28791. *TRIFOLIUM AGRARIUM* L.
 28792. *TRIFOLIUM CLYPEATUM* L.

Distribution.—In the countries along the eastern part of the Mediterranean from Crete to Syria and Palestine.

28793. *TRIFOLIUM SCUTATUM* Boiss.

Distribution.—On the hills in the vicinity of Smyrna, and in Syria and Palestine.

28794. TALAUMA MUTABILIS Blume.

From Buitenzorg, Java. Presented by the director, Department of Agriculture. Received June 3, 1910. Numbered September, 1910.

Variety *splendens*.

Distribution.—Along the banks of the rivers in the interior of the province of Bantam, Java.

28796 and 28797.

From Port Louis, Mauritius. Presented by Mr. G. Regnard. Received September 23, 1910.

Seeds of the following:

28796. *ARTOCARPUS COMMUNIS* Forst.
 See No. 26936 for previous introduction.
 28797. *MIMUSOPS* sp.

28798. GOSSYPIUM sp.**Wild cotton.**

From Riviere du Rempart, Mauritius. Presented by Mr. G. Regnard, Port Louis, Mauritius. Received September 26, 1910.

See Nos. 28879 and 28880 for note.

28799 and 28800. FERONIA LUCIDA Scheffer.

From Buitenzorg, Java. Presented by the director, Department of Agriculture. Received September 16, 1910.

"This plant is known as *Kawis watoe* in Javanese and *Kawista-batoe* in Malayan. It differs from the wood-apple (*Feronia elephantum*) (S. P. I. No. 25888) in having yellowish petals and anthers instead of reddish as that has; also calyces linear-laciniate instead of ovate-acute as in the latter. Occurs in the province of Rembang, Java." (Extract from Scheffer in *Natuurk. Tijds. Ned. Ind.*, vol. 31, p. 19. 1870.)

28801 to 28809.

From Batum, Caucasus, Russia. Received through Mr. Frank N. Meyer, agricultural explorer, March 31, 1910.

Seeds of the following:

28801. *AMYGDALUS COMMUNIS* L. **Almond.**
 "A very small almond, but with thin shell and of good flavor. Said to come from Persia." (Meyer.)

28801 to 28809—Continued.

28802. AMYGDALUS COMMUNIS L. **Almond.**

"A large almond with a very hard shell. Said to come from Persia." (*Meyer.*)

28803. CORYLUS AVELLANA L. **Hazelnut.**

"A hazelnut called '*Trepizond.*' A very popular variety and much grown in this section of the Caucasus. Quantities of them are exported to England and America. Selling at 6 and 7 rubles per pood (36 pounds)." (*Meyer.*)

28804. CORYLUS MAXIMA Miller. **Filbert.**

"A small filbert, quantities of which are sold locally." (*Meyer.*)

28805. CORYLUS MAXIMA Miller. **Filbert.**

"A filbert called '*Kerasund.*' Grown quite extensively and exported to England and America. Sells at 8 rubles per pood (36 pounds)." (*Meyer.*)

28806. ELAEAGNUS ANGUSTIFOLIA L. **Oleaster.**

"Sold sparingly as a sweetmeat. Said to come from Turkestan." (*Meyer.*)

28807. PISTACIA VERA L. **Pistache.**

"A very white pistache, of rather poor quality. Said to come from Persia." (*Meyer.*)

28808. PRUNUS DOMESTICA L. **Plum.**

"These plums when dried are used stewed with meats and in soups. Said to come from Persia." (*Meyer.*)

28809. PRUNUS CERASUS L. **Cherry.**

"Said to come from Gori, central Caucasus." (*Meyer.*)

28810. CANARIUM LUZONICUM (Blume) Gray. **Pili nut.**

From Nueva Caceres, Philippine Islands. Presented by the Hon. P. M. Moir, judge, 8th judicial district, Province of Ambos Camarines. Received September 22, 1910.

"These nuts grow in the southern part of Luzon and nowhere else in the Philippines. The tree is quite large and fairly pretty. The nut is the richest in flavor of any nut I have ever eaten, and all the Americans in the Philippines think it the finest nut grown. When the nuts are roasted, if you touch a lighted match to one it will burn like a lamp, it is so rich in oil. I think you will have to have them planted in Florida, southern Louisiana, or Mississippi, where the climate is warm and damp, as that is the kind of climate we have in the southern part of Luzon, and our rains are very frequent and abundant. The ground should be well drained. The trees are male and female, and it will take five or six years for them to bear nuts." (*Moir.*)

See Nos. 21860 and 23536 for previous introductions.

28811. PSIDIUM GUAJAVA L. **Guava.**

From Tlacotalpan, Vera Cruz, Mexico. Presented by Mr. Edward Everest. Received September 26, 1910. To be grown in connection with the guava-breeding work.

"An evergreen, arborescent shrub, 10 to 20 feet tall, indigenous to the tropical mainland of America whence it has been introduced to practically all parts of the Tropics. The fruit is round, oblong, or pyriform, the best forms attaining a weight of 8 to 10 ounces. The surface is smooth, yellowish, and the flesh, in which the numerous seeds are embedded, whitish, yellowish, or reddish and usually very aromatic. The quality and flavor vary exceedingly, certain types being flat and insipid, others very sweet, and still others more or less acid. The sweet and subacid sorts may be eaten

28811—Continued.

with cream as a dessert fruit, with sometimes sugar added. From the acid fruits a superior jelly is manufactured. By-products obtained in its manufacture are guava marmalade and guava cheese.

"The guava succeeds practically on all classes of land, even poorly drained land, if it is properly cared for and fertilized. Where the temperature during the winter frequently drops below 26° F., its cultivation ceases to be profitable.

"The seed should be sown thinly in flats and the young plants pricked off about 2 to 3 inches apart; keep dry to prevent damping off. When the plants are 6 inches tall they may be transplanted to the nursery, and they are ready for budding when the stems are hardly half an inch in diameter. If the operation is performed during the winter or spring the plants may readily be budded, using the method of shield budding. To obtain the best results, well-ripened budwood from the current year's growth should be used and the buds tied with grafting tape. With good care the plants are ready for planting in the field nine months after insertion of the bud. Twenty to twenty-five feet apart is a good distance at which to plant the guava." (*P. J. Wester.*)

Seeds.

28812. FURCRAEA sp.

From Nice, France. Presented by Dr. A. Robertson-Proschowsky. Received September 29, 1910.

Bulbils. For description see No. 29320.

28813 to 28815.

From the Gaucin district, Spain. Procured by Mr. R. L. Sprague, American consul, Gibraltar, Spain. Received September 29, 1910.

Seeds of the following:

28813 and 28814. LATHYRUS SATIVUS L.

28813. Large seeded.

28814. Small seeded.

28815. VICIA ERVILLA (L.) Willd.

Bitter vetch.

28816 to 28822. MANGIFERA INDICA L.

Mango.

From Lal-Bagh, Bangalore, India. Procured from Mr. G. H. Krumbiegel, economic botanist with the Government of Mysore, Government Botanic Gardens. Received September 26, 1910.

Seeds of the following; notes by Mr. Krumbiegel:

28816. "Amini. Weight 12 to 15 ounces; size 7 by 3½ inches; color yellowish white with a light-red shade; shape long, with thin seed. Skin thin; pulp yellow and juicy; taste sweet."

28817. "Badami. Weight 10 to 12 ounces; size 4 by 3½ inches; skin greenish yellow with reddish-orange shoulder; pulp fine, dark-cream color, of the finest piquant and delicate flavor. The keeping qualities of this fruit are excellent, and it is generally admitted to be the best of the mangos."

28818. "Mulgoa. Weight 16 to 25 ounces; size 7 by 5 inches; color yellow and green; pulp pale yellow; fiberless; very sweet; thin stone and thick skin. One of the latest varieties. Keeps for a long time; a good variety for shipping; one of the best."

28819. "Puttu. Weight 12 to 18 ounces; size 5 by 4½ inches; color dark green; thick skin; orange-white pulp; stone very small as compared with the size; taste not very sweet; juicy and fiberless."

28816 to 28822—Continued.

28820. "*Raspuri*. Weight 12 to 15 ounces; size 6 by 4½ inches; color greenish yellow with dark spots and red shade; pulp yellow, fiberless; thin skin; taste good; flavor pleasant. Profusely fruiting. One of the earliest varieties."

28821. "*Romani*. Weight 10 to 14 ounces; size 4 by 3½ inches; skin very thin; pulp pale yellow; color varying from pale yellow with reddish spots to golden yellow; taste sweet; stone very small. Fruits on trees look like apples from a distance. A long-keeping variety, quite fit for long journeys."

28822. "*Sundershu*. Weight 15 to 20 ounces; size 8 by 4½ inches; color yellowish red; pulp white; stone thin and flat; skin thick; unripe ones are also sweet; shape long, with a pointed curve like that of a parrot's bill. A late variety."

28823 and 28824.

From Oregon. Presented by Mr. George R. Schoch, R. R. No. 1, Forest Grove, Oregon. Received August 26, 1910.

Seeds of the following:

28823. LATHYRUS POLYPHYLLUS Nutt.

From northwestern Oregon, altitude 800 feet. Crop of 1910.

"A perennial species with violet-colored flowers, abundant in the open coniferous woods throughout western Washington and western Oregon. The plants appear in early spring and become fully mature and dry in July. Stock are not fond of the plant when green, but eat the hay readily." (*C. V. Piper.*)

28824. VICIA GIGANTEA Hook.

Giant vetch.

From northwestern Oregon, latitude 45° 32', longitude 46° 8', altitude 1,000 feet. Crop of 1910.

"A perennial vetch with ochroleucous flowers, growing along the Pacific coast from Sitka to middle California. It grows to a great size, the vines being often 8 to 10 feet long and producing a great abundance of plants and pods. The seeds, however, are ordinarily destroyed by insects. Stock ordinarily will not eat the plants while green and are not particularly fond of the hay. The entire plant turns black on drying." (*C. V. Piper.*)

28825. CATHA EDULIS Forsk.

Khat.

From Aden, Arabia. Procured by Mr. Charles K. Moser, American consul. Received August 24, 1910.

"Khat is the Arabic name for *Catha edulis*, a shrub grown commercially in only two localities in the world, the Yemen and near Harrar in Abyssinia. The word is said to be derived from another Arabic word, kûṭ, meaning food or sustenance, and refers to the most salient property of the plant, that of sustaining one who eats of its leaves under the most extraordinary bodily labor. The Arabs say that life and hard work would be unendurable in their country without khat.

"The shrub is found only in certain localities in the mountains from 3,500 to 5,000 feet above sea level. It will not grow, even in highlands, near salt water, or in any soil containing sand. The height of a full-grown plant varies from 5 to 12 feet, apparently more according to the nature of the climate than to the quality of the soil, as has been demonstrated by the Arabs. It appears that its chief requirements for cultivation are a fair amount of water, a cool but not cold climate, and a soil composed largely of disintegrated stone, well manured with sheep and goat droppings. A peculiarity of the plant is that it will not thrive in soil manured with camel or cattle dung.

28825—Continued.

"In appearance khat is a dark-green shrub of thick foliage, its elliptical leaves varying greatly in size, color, and texture in individual plants. In general the mature leaves will average from $1\frac{1}{4}$ to $1\frac{1}{2}$ inches in length, and from three-eighths to five-eighths of an inch in width, according to the locality in which they are grown.

"Khat is grown altogether from cuttings. Cultivation of it is simple and original. The field is first flooded until the soil has absorbed all the water it can hold; care is taken that the water brings in no sand with it. It is then well mixed with sheep and goat manure and left to 'ripen' for a few days. When the ground is sufficiently dry and 'ripe' they set out the cuttings in shallow holes from 4 to 6 feet apart, with space enough between the rows for pickers to pass easily (usually $2\frac{1}{2}$ to 3 feet). The cuttings grow rapidly and spread widely. They are given shallow hoeing for the first year, by which time the shrub is about 2 feet high, with a spread of perhaps 18 inches. Soft earth is then piled up about the base to conserve all moisture, and the leaves become more numerous. Though it is customary to begin picking the leaves when the plant is a year old, this may not always occur. The Arab follows a different rule. When he sees the leaves being eaten by the birds, he knows they are ripe and of good flavor for the market.

"The khat caravans arrive daily at Aden about 11 a. m. The British Government provides rooms for the storage and sale of the shrub, which later is taxed according to weight. On every 25 pounds of the high-grade kinds the tax is \$0.3244; on the low-grade product (which is used by the common people) the tax is \$0.3244 for every 20 pounds. The only reason advanced for the higher tax being placed on the cheaper khat is that its use is more common and therefore the more to be discouraged.

"Khat is used universally throughout all Arabia. There is no coolie too poor to buy his daily portion of this plant. It is the great fact, next to their religion, in the everyday life of the people. The expense to the native is out of all intelligible proportion to his income, and can only be explained as the Arabs explain it, to wit: that without khat they would not consider life worth living, nor would they ever achieve the energy to do any sustained or arduous work.

"The Arab of Aden who earns 30 cents per day spends at least half of it for khat. In Hodeida the man earning the same wage will average 10 cents per day for the support of his family and expend the other 20 cents wholly on khat. Among the better class the proportion of expenditure is not so high, but it is at least 25 per cent of their incomes, and some of the wealthy will spend several dollars per day for their favorite passion. The fresh leaves and tender stems are always chewed, never brewed or made into any sort of beverage. Nothing is known in Arabia of the chemical constituents of khat." (*Moser.*)

See No. 24714 for previous introduction.

28826. PASSIFLORA EDULIS Sims.**Passion flower.**

From Melbourne, Australia. Presented by Mrs. Alexander Graham Bell, Washington, D. C. Received September 29, 1910.

"Passion fruit will grow in the States; it prefers a loose sandy-loam soil, but must be high enough up to be out of the reach of frosts, and near the sea for preference, within, say, 10 miles. It requires plenty of manure and should be grown on a wire trellis, that is, an ordinary fence with posts 15 feet apart. In place of having the wire as in the fence, nail a crosspiece about 18 inches long on the top of each post and run two wires along this crosspiece. Train the vine up by the main stem until the wires are reached, then run an arm out each side along the wires. The lateral growths will hang down like a curtain and the fruit bears on this lateral growth. Plant vines 15 feet apart, one between each two posts; train vines up a stick until they reach the wire. Rows to be 15 feet apart. The best manure for them is composed of 7 hundredweight

28826—Continued.

of bone dust, 5 hundredweight of superphosphate, and 3 hundredweight of potash, making 15 hundredweight to an acre. If the winter is fairly warm a winter crop can be grown by cutting off the lateral growth a foot below the wires in the late spring or early summer and then manuring, but if the winter is not mild I would simply go in for the natural summer crop—prune as above late in winter and manure early in spring. The vines are raised in seed boxes from the seed. Simply wash the pulp out of the fruit and dry the seed; plant out when about 6 inches high. Do not allow any lateral growth until the wires are reached. We plant in Australia about the end of September or the beginning of October. Shelter young plants until they get started. Some fruit will be obtained the first season and a full crop the second season. The vines are about done in four years. The passion flower does wonderfully well in the sandstone country around Sydney, yet it grows almost wild in the semitropical climate of the northern rivers of New South Wales." (*James Moody, Toomuc Valley Orchards, Melbourne, Australia.*)

See Nos. 1906 and 12899 for description.

28827 and 28828.

From Puerto de Orotava, Teneriffe, Canary Islands. Presented by Dr. George V. Perez. Received September 16, 1910.

Seeds of the following:

28827. CYTISUS PROLIFERUS L.**Tagasaste.**

Variety *palmensis*. "This is a splendid forage plant and very drought resisting. The failures with it are due to ignorance of farmers and to not cutting back the plant. Cattle and horses have to learn to eat it; they relish it ever after. In the island of Palma (Canary Islands), where it is native from time immemorial, it has been used with the greatest success possible. It is quite as nutritious as lucern and does not want irrigation. I know of nothing that will fatten cattle and horses so much. In Palma there are large districts planted with it where cattle and even pigs eat it at liberty. Chaffed and mixed with straw it is excellent. The seed must be scalded in boiling water before sowing." (*Perez.*)

28828. ECHINUM SIMPLEX DC.

"The so-called *Pride of Teneriffe*, a lovely, showy, native plant, remarkable for its single tall spike of white flowers reaching from 2 to 3 yards high. From what I have seen and observed I have come to the conclusion that besides being a very ornamental plant it could be turned into a most valuable fodder, beating the prickly comfrey, over which it has the advantage, like all plants of the Canary flora, of being drought resistant. The idea is entirely my own after watching in one of my properties how greedily my cows eat it." (*Perez.*)

28829 to 28832.

From Togo, Africa. Presented by Mr. G. H. Pape, through Mr. A. B. Conner, scientific assistant, Chillicothe, Tex. Received September 29, 1910.

Seeds of the following:

28829. VIGNA UNGUICULATA (L.) Walp.**Cowpea.**

Tan.

28830 to 28832. VOANDZEA SUBTERRANEA (L.) Thouars.**Woandsu.**

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28833 to 28874.

From Ventimiglia, Italy. Presented by Mr. Alwin Berger, La Mortola. Received September 6, 1910.

Seeds of the following:

28833. ACER OBLONGUM Wall.**Maple.**

"Tree up to 50 feet in height, with glabrous, entire ovate-lanceolate leaves, coriaceous and glaucous beneath." (*Bailey.*)

See No. 8659 for previous introduction.

Distribution.—Slopes of the temperate Himalayas at an altitude of 2,000 to 5,000 feet, extending from Kashmir to Sikkim in India, and in the vicinity of Hongkong, China, and in the Nansei Islands.

28834. ALTHAEA SULPHUREA Boiss. and Hohen.

Distribution.—Lower slopes of the mountains in northern Persia, Afghanistan, and Sungaria.

28835. ASPARAGUS ACUTIFOLIUS L.

See No. 17981 for description.

Distribution.—The countries bordering on the Mediterranean Sea from Portugal and Spain through Italy and Greece to Syria, and in northern Africa.

28836. BALLOTA PSEUDODICTAMNUS (L.) Benth.

"A white-woolly, herbaceous plant, wool densely floccose, leaves orbiculate, entire or obscurely crenate, base broadly cordate, petiole short, corolla white spotted with red, upper lip cut at the apex, bearded within." (*Willkomm and Lange, Prodrromus Florae Hispanicae.*)

Distribution.—In waste places and dry fields in Greece and the island of Crete.

28837. BALLOTA HISPANICA (L.) Benth.

"An herbaceous plant, stem white woolly, leaves broadly ovate, obtuse, velvety above, floccosely woolly below, corolla whitish." (*Willkomm and Lange, Prodrromus Florae Hispanicae.*)

Distribution.—Dry and stony places in Spain, Italy, Sicily, and Dalmatia.

28838. BENINCASA CERIFERA Sav.(?)**28839. BERBERIS NAPAULENSIS (DC.) Spreng.****Barberry.**

"The fruit of this evergreen species is edible. The plant is hardy to latitude 59° 55' in Norway (Schuebeler)." (*Von Mueller.*)

See No. 8853 for previous introduction.

Distribution.—On the lower slopes of the Himalayas at an elevation of 4,000 to 8,000 feet from Gurhwal to Bhutan in northern India, and on the Khasi Hills in southern India.

28840. BUDDLEIA BRASILIENSIS Jacq.

"An evergreen tender shrub with orange flowers." (*Johnson's Gardeners' Dictionary.*)

A shrub with ovate leaves united around the square stem, native of Brazil.

28841. BUDDLEIA GLOBOSA Hope.

See No. 1576 for description.

28833 to 28874—Continued.**28842. CELTIS OCCIDENTALIS L.****Hackberry tree.**

"Height reaching to 80 feet. Will grow tolerably well even on the poorest soil. (*B. E. Fernow.*) Hardy as far north as Christiania. Wood rather soft, difficult to split." (*Von Mueller.*)

28843. CISTUS ALBIDUS × CRISPUS.**28844. CLEMATIS INTEGRIFOLIA L.**

"Herbaceous, erect, becoming 2 feet high; leaves rather broad; flowers solitary, blue. Blooms from June to August." (*Bailey.*)

Distribution.—Central Europe and Asia, extending from Austria and Hungary eastward through central Russia and Siberia.

28845. CRATAEGUS CRENULATA Roxb.

"Shrub with branchlets and petioles rusty pubescent, at length glabrous; leaves oblong to oblanceolate, leathery, bright green and glossy above; corymbs glabrous; fruit globose, bright orange-red; blooms in May and June." (*Bailey.*)

Distribution.—Dry places on the slopes of the Himalayas at an altitude of 2,500 to 8,000 feet, between Sirmur and Bhutan, northern India.

28846. CRATAEGUS sp.**28847. CROTALARIA CAPENSIS Jacq.**

"Stout, much-branched shrub, 4 to 5 feet high. Cultivated in Florida." (*Bailey.*)

Distribution.—Common in the eastern districts of Cape Colony, extending northward to Durban.

28848. EUCALYPTUS CREBRA Muell.**Narrow-leaved ironbark.**

"A tall tree. Bark persistent throughout, dark, almost blackish, ridged, and deeply furrowed, solid; timber heavy, hard, elastic, and durable; used for railroad ties, piles, fence posts, and in the construction of bridges and wagons; also suitable for splitting into palings." (*Bailey.*)

See No. 769 and 1622 for previous introductions.

Distribution.—Between the Flinders and Lynd Rivers in North Australia, in the vicinity of Moreton Bay in Queensland, and along the Hastings River in New South Wales.

28849. EUCALYPTUS LEHMANNI (Schauer) Preiss.**Lehmann's gum.**

"A tall shrub or small tree; bark coming off in irregular sheets, roughish and reddish; flowers greenish yellow. A valuable ornamental tree. Blooms July to September.

Distribution.—West Australia, extending along the southern coast east to King George Sound, and on stony hills from Bald Island and Stirling Mountains eastward to Cape Arid.

28850. PODACHAENIUM EMINENS (Lag.) Baill.

"A tall shrub; on account of the grandeur of its foliage in requisition for scenic effects." (*Von Mueller.*)

Distribution.—Southern Mexico and Central America, extending from Orizaba southeastward through Guatemala to Costa Rica.

28851. IRIS ALBOPURPUREA Baker (?)

Received in a shipment from Japan without any information as to the locality from which it came.

28833 to 28874—Continued.

28852. *IRIS ATTICA* Boiss. and Heldr.

"Stem short or almost none; leaves wide, falcate, equaling or longer than the spathe; limb violet or yellow, external segments slightly shorter, reflexed, bearded within." (*Bailey*.)

Distribution.—In stony places on the lower slopes of Mount Parnassus and in the province of Attica in Greece.

28853. *IRIS CENGIALTI* Ambrosi.

"Resembles *Iris pallida*, of which it is probably merely a dwarf variety; leaves 6 inches long, stem about as long as leaves, flowers bright lilac, outer segments with a white beard. Blooms May and June." (*Bailey*.)

Distribution.—Slopes of the Tyrolean Alps in southern Austria and northern Italy.

28854. *IRIS SPURIA DAENENSIS* Kotschy.

Distribution.—This subspecies comes from the southern part of Persia.

28855. *IRIS POETIDISSIMA* L.

"This plant is very distinct and is easily recognized by the odor of the broken leaves. The capsules remain on the plant in the winter, bursting open and displaying rows of orange-red berries. The flowers are rather inconspicuous." (*Bailey*.)

Distribution.—Central and southern Europe and eastward to Afghanistan and in Algeria.

28856. *IRIS GERMANICA* L.

"Leaves 1 to 1½ feet long; stem 2 to 3 feet high; spathe valves tinged with purple; outer segments obovate-cuneate, 2 to 3 inches long; beard yellow; inner segments as large, obovate, connivent. Blooms in early May and June." (*Bailey*.)

See No. 9103 for previous introduction.

Distribution.—Throughout central and southern Europe.

28857. *IRIS HALOPHILA* Pallas.

"Leaves pale green, 1 to 1½ feet long; stem stout, terete, 1½ to 2 feet long, often bearing one to two spicate clusters below the end one; limb pale yellow; outer segments with an orbicular blade one-half to three-fourths of an inch broad, shorter than the claw, which has a bright-yellow keel and faint lilac veins; inner segments shorter, erect." (*Bailey*.)

Distribution.—Eastern Europe and southern Asia, extending from Austria eastward through Turkey, Asia Minor, and the Caucasus region to Mongolia and Kashmir.

28858. *IRIS CHAMAEIRIS ITALICA* (Parl.) Baker.

"Leaves 3 to 4 inches long, one-half inch broad; stem very short, flowers dark violet; outer segments obovate-cuneate, tinged and veined with brown; inner segments oblong. Blooms in May." (*Bailey*.)

Distribution.—Southern Europe, extending from southern France and northern Italy through Dalmatia.

28859. *IRIS LUTESCENS* Lam.

"Leaves 6 to 9 inches long; stem equaling the leaves; flowers pale yellow; outer segments obovate-cuneate, 2 to 2½ inches long, pale yellow, streaked with pale brown, undulate; inner segments broader, suddenly narrowed to a claw which is streaked with purple, crenulate." (*Bailey*.)

Distribution.—Stony mountainous slopes in the southern part of France.

28833 to 28874—Continued.**28860. IRIS SIBERICA L.**

"Compact, tufted; leaves green, not rigid, 1 to 2 feet long; stem slender, terete, fistulous, much overtopping the leaves, simple or forked, bearing several clusters of flowers; limb bright lilac blue; outer segments $1\frac{1}{2}$ to 2 inches long, with orbicular blade gradually narrowed to a slender claw, veined with bright violet, whitish toward the claw; inner segments shorter, erect. The plants form large compact clumps producing many long flowering stems from the center." (*Bailey*.)

See Nos. 9104 and 13232 for previous introductions.

Distribution.—Throughout central and southern Europe and eastward to eastern Siberia.

28861. IRIS MISSOURIENSIS Nutt. (?)**28862. IRIS CHAMAEIRIS OLBIIENSIS (Henon) Baker.**

Same as No. 28858 except "flowers are bright yellow." (*Bailey*.)

Distribution.—Northern Italy and southern France and eastward through Dalmatia.

28863. IRIS ORIENTALIS Miller.

Variety *gigantea*.

Distribution.—Asia Minor and Syria, and the island of Samoa.

28864. IRIS PARADOXA Stev.

"Plants dwarf; leaves linear; flowers large, outer segments reduced to a mere claw, dark, covered with pile; inner segments 2 inches long, orbicular, lilac to white. A flower with singular combinations of color. Grows in dry situations, but requires shelter in winter." (*Bailey*.)

Distribution.—Dry sandy places in the Transcaucasian region of southern Russia and in northern Persia.

28865. IRIS PRISMATICA Pursh (?).**28866. IRIS RUTHENICA Dryand.**

"Leaves 5 to 12 inches long, in crowded tufts; stem slender, 3 to 6 inches long, but often obsolete; tube twice as long as the ovary; outer segments with an oblong blade rather shorter than the claw, lilac, violet scented. Blooms in April and May." (*Bailey*.)

Distribution.—Eastern Europe and central Asia, extending from Austria eastward through Russia and Siberia to eastern China and Mongolia.

28867. IRIS SETOSA Pall. (?)

Distribution.—Eastern Siberia, Japan, and in northwestern North America.

28868. IRIS HALOPHILA SOGDIANA (Bunge) Skeels.

(*Iris sogdiana* Bunge, Academie de St. Petersburg, Memoires des Savants Etrangers, vol. 7, p. 507, 1850-54.)

(*Iris gueldenstaediana sogdiana* Baker, Irideae, p. 14, 1892.)

The name *Iris gueldenstaediana* was published by Lepechin (Acta Academiae Petropolitanae for 1781, pt. 1, p. 292, pl. 8) in 1784. But Pallas in 1773 (Reise durch Verschiedene Provinzen des Russischen Reichs, vol. 2, p. 733) had published the name *Iris halophila* for the same species. The earlier name should be used for the species, which necessitates transferring the subspecies published by Baker to *I. halophila*.

Same as No. 28857 but "with gray-lilac flowers (*Bailey*)." "

Distribution.—Throughout Asia, from Asia Minor and the Caucasus region eastward to Kashmir and Mongolia.

28833 to 28874—Continued.**28869. IRIS UNGUICULARIS Poir.**

"Leaves about six in a tuft, finally $1\frac{1}{2}$ to 2 feet long, bright green; tube 5 to 6 inches long, filiform, exserted from the spathe; limb bright lilac, rarely white; outer segments $2\frac{1}{2}$ to 3 inches long, 1 inch broad, with a yellow keel, streaked with lilac on a white ground at the throat; inner segments oblong. Blooms in January and February. Not hardy." (*Bailey*.)

Distribution.—A fragrant-flowered species coming from Algeria.

28870. IRIS XIPHIIUM L.**Spanish iris.**

"Leaves about 1 foot long, stem 1 to 2 feet high; pedicel long; tube obsolete; outer segments 2 to $2\frac{1}{2}$ inches long; violet-purple, yellow in the center; inner segments as long, but narrower. Blooms in late June." (*Bailey*.)

Distribution.—Spain and southern France, ascending to an elevation of 6,000 feet, and in northern Africa.

28871. MORAEA sp.

NOTE.—This was received as *Moraea aurantiaca* Eckl., which seems never to have been described.

28872. PISTACIA LENTISCUS L.

See No. 3011 for description.

Distribution.—The countries bordering on the Mediterranean from Spain through Italy, Greece, and Asia Minor to Syria, and in northern Africa.

28873. SALVIA SCLAREA L.

"A plant of exceptional interest. Cultivated for its culinary and medicinal value and also for ornament, but its ornamental value lies not in the flowers, which are pale purple or bluish, but in the colored bracts or floral leaves at the tops of the branches." (*Bailey*.)

Distribution.—Southern Europe and western Asia, extending from Germany eastward through Austria, Italy, Turkey, and southern Russia to Persia, and in northern Africa.

28874. VIBURNUM TINUS L.

See No. 2192 for description.

Distribution.—Southern Europe, extending from Portugal and Spain through southern France and Italy to Dalmatia, and in northern Africa.

28875. BELOU MARMELOS (L.) W. F. Wight.**Bael.**

From Pusa, Bengal, India. Presented by Dr. A. Howard, of the Agricultural Research Institute, through Maj. A. T. Gage, Royal Botanic Gardens, Sibpur, Calcutta, India. Received September 28, 1910.

Dalsing Serai.

See No. 24450 for description of this species.

28876. VITIS sp. (?)

From Hollywood, Cal. Presented by Mr. E. D. Sturtevant. Received September 29, 1910.

"Native of the southern part of the state of Vera Cruz, Mexico. Said to bear beautiful scarlet flowers. It is hardy here, but does not bloom. It might do so in south Florida." (*Sturtevant*.)

28877. CYNARA SCOLYMUS L.**Artichoke.**

From Maison Carree, Algeria. Presented by Dr. L. Trabut, Mustapha-Alger, North Africa. Received September 29, 1910.

Violet Provence.

28878. PASSIFLORA EDULIS Sims.**Passion flower.**

From Patras, Greece. Grown by Mrs. Crowe. Presented by Dr. A. Donaldson Smith, American consul, Aguascalientes, Mexico. Received September 29, 1910.

"I have tasted the passion fruit in many places, but the fruit from which these seeds were taken was the best." (*Smith.*)

See No. 25874 for distribution of this species.

28879 and 28880. GOSSYPIUM sp.**Wild cotton.**

From Mauritius. Presented by Mr. G. Regnard, Port Louis, Mauritius. Received September 26, 1910.

Seeds of the following:

28879. From Yemen, Black River. **28880.** From Carcenass, Black River.

"These cottons (see also No. 28798) grow particularly at the NNE. and NW. of the island at different altitudes and under different soil and climatic conditions without varying in growth and shape." (*Regnard.*)

PUBLICATION OF NEW NAMES.

- 28525. *TRITOMA NORTHIAE* (Baker) Skeels.
- 28526. *TRITOMA TUCKII* (Baker) Skeels.
- 28526 (in note). *TRITOMA SARMENTOSA* (Andr.) Skeels.
- 28663. *LEBECKIA CUSPIDOSA* (Burch.) Skeels.
- 28673. *ECHEVERIA HOVEYI* Rose n. sp.
- 28729. *OPHIOBOSTRYX VOLUBILIS* (Harvey) Skeels.
- 28730. *MONDIA WHITEII* (Hook. f.) Skeels.
- 28740. *PECTINEA PAUCIFLORA* (Thouars) Skeels.
- 28766. *HELYGIA PADDISONI* (Baker) Skeels.
- 28781. *MELOCANNA BACCIFERA* (Roxb.) Skeels.
- 28793. *ARGANIA SPINOSA* (L.) Skeels.
- 28868. *IRIS HALOPHILA SOGDIANA* (Bunge) Skeels.
- 19897. $\times$ *ASSONIA CAYEUXII* (Andre) Skeels.

(*Dombeya cayeuxii* Andre, Revue Horticole, vol. 69, p. 545, 1897.)

The name *Dombeya* (Cavanilles, 1787) seems to have been quite generally used to designate a genus of sterculiaceae shrubs or small trees, but as the same name was originally used (L'Heritier, 1784) for a genus belonging to the family Bignoniaceae, for which the name *Tourretia* (Fougeroux, 1787) was later proposed, it should not be applied to the genus established by Cavanilles. In fact, the latter author on a previous page of the same work in which he published *Dombeya* established the genus *Assonia* with the single species *A. populnea* (Tertia Dissertatio Botanica, p. 120, pl. 42, fig. 1, 1787). This species is now recognized as congeneric with the various species referred to Cavanilles's *Dombeya*, and *Assonia* should therefore be considered the valid name for the genus in question. It should be noted that both the names *Assonia* and *Dombeya* were proposed by Cavanilles in 1786 (*Secunda Dissertatio Botanica*, app.), but without mention of species.

Cuttings of the species listed were received in 1907 as "*Dombeya spectabilis*(?)" and were later distributed. Dr. Franceschi of the Montarico Nursery, Santa Barbara, Cal., who received some of the cuttings, called attention to the identity of the plant with *Dombeya cayeuxii* Andre.

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B. T. GALLOWAY, *Chief of Bureau.*

TIMOTHY RUST IN THE UNITED STATES.

BY

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LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF CHIEF OF BUREAU,
Washington, D. C., May 26, 1911.

SIR: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 224 of the series of this Bureau the accompanying manuscript, entitled "Timothy Rust in the United States," by Mr. Edward C. Johnson, of the Office of Grain Investigations of this Bureau.

Timothy rust, first reported in the United States in 1882, has become an important problem in recent years. In 1906 it was abundant in the timothy-breeding plats at the Arlington Experimental Farm, near Washington, D. C. Since then it has become widespread, causing considerable damage in many localities, and its ultimate distribution over all timothy-growing regions where conditions are favorable to rust development is to be expected. This paper discusses the present known distribution and relationships of the rust of timothy and summarizes previous investigations of this disease in Europe and America. New information on its physiological specialization and methods of winter survival and on the resistance of timothy strains and varieties to rust is also presented.

Respectfully,

WM. A. TAYLOR,
Acting Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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TIMOTHY RUST IN THE UNITED STATES.

DISTRIBUTION OF THE RUST OF TIMOTHY.

Rust of timothy was reported in this country by Trelease as early as 1882.¹ Farlow and Seymour, on the basis of this report, mentioned *Puccinia graminis* on *Phleum pratense* L. from the United States in their "Host Index of the Fungi of the United States" (1888). Rust of timothy was reported as causing considerable damage in the experimental plats at the Iowa experiment station in 1891.² From 1891 to 1906 the parasite seems to have been little in evidence throughout the country, and the writer has been unable to find any mention of it during those years.

In 1906 the rust became epidemic in the experimental plats at the Arlington Experimental Farm. In 1907 it was epidemic at points in New York and Virginia; it was also reported from Delaware, West Virginia, and Ontario, Canada. In 1908 this rust was widespread and caused much damage in New York, Pennsylvania, Delaware, Maryland, and Virginia; it was also reported from West Virginia, Ohio, Michigan, Wisconsin, and Minnesota. In 1909 the rust was common in many of the States mentioned and in addition was reported from Indiana, Kentucky, Iowa, and Maine. In 1910 it was observed in many States from which it had been previously reported, and in considerable quantity in Virginia, New York, Michigan, and Minnesota. In the last State it was collected at both New Richland and Owatonna, and in August was exceedingly abundant in timothy pastures around Crookston. Thus, from being only locally observed in 1906, this rust was widespread in 1909 and 1910, having been reported from Maine to Ontario and northern Minnesota, and south to Iowa, Kentucky, and Virginia.³

¹ Trelease, William. Parasitic Fungi of Wisconsin. Transactions of the Wisconsin Academy of Sciences, 1882, p. 131. A specimen collected in Wisconsin was kindly sent to us for examination by Dr. Trelease from the Missouri Botanical Gardens. It was rather unsatisfactory, as it consisted of only one rusted leaf, and thus may have been inaccurately determined, leaving some doubt as to the authenticity of this early report.

² Wilson, J., Curtis, C. F., and Kent, D. A. Time of Sowing Grass Seed. Bulletin 15, Iowa Agricultural Experiment Station, 1891, pp. 285-286.

³ The writer is indebted to botanists and plant pathologists at the various agricultural experiment stations and to J. J. Davis, M. W. Evans, E. M. Freeman, R. A. Harper, Frank D. Kern, W. J. Morse, C. V. Piper, H. N. Vinal, H. J. Webber, and others who have answered letters of inquiry in regard to the rust on timothy or have given information as to its prevalence in various localities.

DESCRIPTION OF TIMOTHY RUST.

The timothy rust is very similar in general appearance and morphological characteristics to *Puccinia graminis* Pers. on wheat. It attacks both leaf and stem, forming long, yellowish-brown uredo pustules and dark-brown to black teleuto pustules, which rupture the epidermis. At times it also attacks the head, often preventing the formation of seed. The uredospores are most prevalent, while the teleutospores are less abundant.

The uredospores are 18 to 27 μ in length and 15 to 19 μ in width; the teleutospores, 38 to 52 μ in length and 14 to 16 μ in width. This is the same range as that of the corresponding spores of *Puccinia graminis* Pers. on wheat, but the variation is not quite as great as in the wheat rust. The teleutospores are constricted in the middle and have a much thickened, round or pointed apex and pedicels of medium length, and closely resemble those of the typical *Puccinia graminis* Pers.

RELATIONSHIP AND PHYSIOLOGICAL SPECIALIZATION OF
TIMOTHY RUST.

In 1908 and 1909 inoculation experiments on various grasses were undertaken at Washington, D. C., to determine the relationship of the rust of timothy to rusts of other hosts in this country and to ascertain whether or not it is the same form as that which occurs in Europe. Collections were made at the Arlington Experimental Farm, and fresh material in the uredo stage was kept growing in the greenhouses at Washington, D. C. All inoculations were made on young, fresh leaves of the host plants growing in pots. The plants were kept moist for 48 hours after inoculation by placing the pots in moist chambers consisting of large bell jars placed in pans containing sand and a little water. In this way a thin film of water soon condensed on the leaves and remained as long as the plants were covered. This gave ideal conditions for spore germination and for infection. The results of these inoculations are reported in Table I.

TABLE I.—Results of experiments in inoculating various grasses with uredospores of rust.

Serial No.	Date of inoculation.	Source of inoculating material.	Varieties of plants inoculated.	Number of leaves inoculated.	Number of successful inoculations during incubation period of 17 to 21 days.
1	Jan. 25, 1908	<i>Phleum pratense</i>	<i>Triticum vulgare</i>	10	0
2	Feb. 3, 1908	<i>Phleum pratense</i>	<i>Phleum pratense</i>	25	0
3	Jan. 25, 1908	<i>Phleum pratense</i>	<i>Hordeum vulgare</i>	10	0
4	do.....	do.....	<i>Avena sativa</i>	10	6
5	Feb. 18, 1908	do.....	do.....	20	11
6	Feb. 3, 1908	<i>Avena sativa</i>	<i>Phleum pratense</i>	23	0
7	do.....	<i>Phleum pratense</i>	do.....	25	19
8	Jan. 25, 1908	do.....	<i>Secale cereale</i>	5	1
9	Feb. 18, 1908	do.....	do.....	36	7
10	Feb. 7, 1908	do.....	<i>Festuca elatior</i>	24	6
11	Feb. 4, 1908	do.....	do.....	42	0
12	Feb. 20, 1908	do.....	<i>Dactylis glomerata</i>	22	6
13	Jan. 23, 1909	do.....	do.....	25	1
14	Feb. 4, 1909	do.....	do.....	16	6
15	Feb. 13, 1909	do.....	do.....	59	9
16	Feb. 20, 1908	do.....	<i>Arrhenatherum elatius</i>	18	0
17	Jan. 27, 1909	do.....	do.....	18	6
18	Feb. 4, 1909	do.....	do.....	3	2
19	do.....	do.....	<i>Poa compressa</i>	18	6
20	Feb. 8, 1909	do.....	do.....	29	7
21	do.....	do.....	<i>Poa pratensis</i>	33	0
22	Feb. 7, 1908	do.....	<i>Elymus virginicus</i>	60	0
23	Jan. 27, 1909	do.....	do.....	10	0
24	Feb. 4, 1909	do.....	do.....	33	0
25	Jan. 23, 1909	do.....	<i>Elymus canadensis</i>	25	0
26	Feb. 8, 1909	do.....	do.....	9	0
27	Mar. 7, 1908	do.....	<i>Elymus robustus</i>	16	0
28	Feb. 20, 1908	do.....	<i>Agropyron occidentale</i>	14	0
29	do.....	do.....	<i>Hordeum jubatum</i>	24	0
30	Mar. 7, 1908	do.....	<i>Phalaris arundinacea</i>	17	0
31	do.....	do.....	<i>Holcus lanatus</i>	28	0
32	Feb. 4, 1909	do.....	<i>Hystrix hystrix</i>	44	0
33	Feb. 8, 1909	do.....	<i>Agrostis alba</i>	31	0
34	Feb. 13, 1909	do.....	do.....	11	0
35	Jan. 23, 1909	do.....	<i>Bromus unioloides</i>	40	0
36	Jan. 27, 1909	do.....	do.....	7	0

The rust rather easily transferred to *Avena sativa* (17 out of 30 inoculations), *Secale cereale* (8 out of 41 inoculations), *Festuca elatior*¹ (6 out of 66 inoculations), *Dactylis glomerata* (22 out of 122 inoculations), *Arrhenatherum elatius* (8 out of 47 inoculations), and *Poa compressa* (13 out of 47 inoculations). Inoculations on other grasses produced no infection. Similar results were obtained by Eriksson² in inoculation experiments with this rust on *Avena sativa*, *Secale cereale*, and *Festuca elatior*.¹ No inoculations on *Dactylis glomerata*, *Arrhenatherum elatius*, or *Poa compressa* are cited in his report. Direct inoculation on *Triticum vulgare* and *Hordeum vulgare* gave negative results in 10 trials each, thus corresponding to the negative results in numerous similar trials of Eriksson.² From these

¹ The tall meadow fescue was used in our work. It is probable that the same variety was used by Eriksson, as this is the common form known by that name in Sweden.

² Eriksson, Jakob. Ist der Timotheegrassrost eine selbständige Rostart oder nicht? Öfversigt af Kongliga Svenska Vetenskaps-Akademiens Förhandlingar, no. 5, 1902, pp. 193-196.

experiments it may be concluded that the rust in the United States and the rust in Europe are identical, and the statement by Eriksson¹ that it is not a well-fixed species is substantiated. Although timothy rust can easily be transferred to *Avena sativa*, Eriksson¹ and Carleton² have shown that the uredo of *Puccinia graminis avenae* Erikss. and Henn. can not be made to grow on timothy. This rust, however, can easily be transferred to *Dactylis glomerata* and *Arrhenatherum elatius*.³ Timothy rust also transfers to these hosts (Table I). These rusts, therefore, although not identical, have many characteristics in common, which indicates that there probably is a very close relationship between the two.

A small number of experiments to test whether or not the timothy rust can be transferred by means of bridging hosts to various cereals which are not successfully infected directly from timothy were tried and it was found that by using *Avena sativa* as a bridging host the rust easily transferred to *Hordeum vulgare* (4 times in 10 trials); by using *Festuca elatior* it transferred to *Hordeum vulgare* (twice in 10 trials) and to *Triticum vulgare* (once in 10 trials); and by using *Dactylis glomerata* it transferred to *Triticum vulgare* (once in 5 trials). By the use of the bridging hosts the rust undoubtedly could be made to transfer to many grasses on which it will not grow when coming directly from timothy, but on which it might continue to grow after such a transfer. That this to some extent takes place in nature is very probable, and these trials, together with recent experiments of a similar nature on the rusts of grains,⁴ throw much light on the possible origin of many of the so-called "physiological species" of rust.

ÆCIDIAL STAGE AND NOMENCLATURE OF TIMOTHY RUST.

The æcidial stage of the rust is not definitely known. Eriksson and Henning⁴ noticed that the timothy in the neighborhood of barberries was not affected, while other grasses in the same locality were rusted. In two trials in 1891 they were unable to secure infection on timothy with æcidiospores from *Berberis vulgaris*. In 1892-3 æcidia on *Berberis vulgaris* were obtained by them after inoculation with teleutospores of timothy rust ones in nine trials, and that in only one place of inoculation against 92 places inoculated with negative results. This one positive result may have been due to accidental infection from some other source, as two leaves on the same bush

¹ Loc. cit.

² Carleton, Mark Alfred. Cereal Rusts of the United States. Bulletin 16, Division of Vegetable Physiology and Pathology, U. S. Dept. of Agriculture, 1899, pp. 61-62.

³ Freeman, E. M., and Johnson, Edward C. The Rusts of Grain in the United States. Bulletin 216, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1911, p. 16.

⁴ Eriksson, Jakob, and Henning, Ernst. Die Haupt-Roststadien einer neuen Untersuchung über die Getreideroste. Zeitschrift für Pflanzenkrankheiten, vol. 4, 1904, p. 140.

which had not been artificially inoculated also produced æcidia.¹ In 1895 Eriksson again made inoculation experiments on the barberry with the teleutospores of this rust, but in 25 inoculations none was successful.² In this country Kern³ in 1908 observed eight unsuccessful inoculations on the barberry.

From their results Eriksson and Henning concluded that timothy rust does not form its æcidial stage on the barberry, while Kern³ says that "The one positive result mentioned ought, it seems, [to] be accorded more weight than all the negative ones together, and proves that it [timothy rust] does, even if with difficulty, form its æcial stage upon the barberry." Eriksson and Henning regard the rust as a distinct species and name it *Puccinia phlei-pratensis*, while Kern considers it "a race of *Puccinia poculiformis* (*graminis*) or a so-called physiological species." Evans accepts the name *Puccinia phlei-pratensis*,⁴ and in a discussion of the development of the uredo mycelia of the cereal rusts shows that there are differences in the details of infection of this rust and *Uredo graminis*, which, although slight, are well marked. In a later paper Kern⁵ states that he is still of the opinion that this rust is not entitled to specific rank and would include it under "*Puccinia poculiformis* (Jacq.) Wettst.," i. e., *Puccinia graminis* Pers. He modifies his previous statement as to its being a physiological species and thinks it might better be considered a variety or subspecies, "since it does, as previously pointed out, possess some slight morphological differences from the typical form, particularly in the smaller æcial cups and the more delicate uredinal mycelium."

From the physiological specialization of this rust, as shown in experiments above reported; from its distinctive method of infection from the uredospore, as described by Evans; from the difficulty with which it produces its æcidium on barberries, as shown by Eriksson and Henning; and from the delicacy of the mycelium of the uredo stage as compared with the typical *graminis* form, as cited by Kern, it is evident that the rust of timothy has many distinctive characteristics, and, even if not well fixed, is highly specialized. Whether or not it should be regarded as a distinct species is, perhaps, debatable.

¹ Eriksson, Jakob, and Henning, Ernst. Die Getreideroste, 1894, p. 137.

² Eriksson, Jakob. Ist der Timotheengraurost eine selbständige Rostart oder nicht? Öfverlagt af Kongliga Svenska Vetenskaps-Akademiens Förhandlingar, no. 5, 1902, p. 191.

³ Kern, F. D. The Rust of Timothy. Torreya, vol. 9, January, 1909, p. 4.

⁴ Evans, I. B. Pele. The Cereal Rusts. The Development of Their Uredo Mycelia. Annals of Botany, vol. 21, no. 84, 1907, pp. 448-449. "The substomatal vesicle is a very definitely shaped body closely resembling that of *Uredo graminis*, but narrower. * * *. It differs from *Uredo graminis* chiefly in the fact that the end from which the hypha springs does not cling to the head of the guard cell."

⁵ Kern, F. D. Further Notes on Timothy Rust. Proceedings of Indiana Academy of Science, 1909, pp. 417-418.

Some method of differentiating this rust in literature from the common *graminis* forms is necessary, however, and unless further experiments should show that it can produce its æcidium on the barberry, and until such experiments have been performed, the writer favors the use of the specific name *Puccinia phlei-pratensis* Erikss. and Henn.

WINTER SURVIVAL OF TIMOTHY RUST.

In 1908 an effort was made to determine how the rust survives the winter at the Arlington Experimental Farm. Timothy plants were removed from the field on January 19 and March 12 and were immediately potted and placed in a greenhouse at Washington, D. C., where they could be carefully watched and any further development of rust noted. Table II shows the results of these experiments.

TABLE II.—Results of experiments on the winter survival of the rust of timothy.

Serial No.	Placed in greenhouse.	Observations.					
		Date.	Result.	Date.	Result.	Date.	Result.
1	1908. Jan. 20	1908. Jan. 22	Four unopened pustules near tip of one leaf, several flecks in center.	1908. Jan. 28	Pustules near tip not open, three fresh open pustules at center where flecks occurred.	1908. Feb. 3	End of leaf dried, numerous fresh pustules over remainder of leaf.
2	...do....	...do....	No rust pustules, no flecks.	...do....	No rust.....	...do....	No rust.
3	...do....	...do....	Seven unopened pustules on upper side of one leaf, several on lower.	...do....	Several fresh open pustules on both sides of leaf, several new pustules.	...do....	Leaf covered with vigorous pustules.
4	...do....	...do....	Six pustules near tip on upper side of one leaf, six on lower.	...do....	Six pustules on upper side of leaf, six on lower near tip, vigorous; three fresh pustules on upper side; three on lower near center, two of them open.	...do....	New pustules still forming, old ones vigorously producing spores.
5	...do....	...do....	One pustule on middle of upper side of one leaf, leaf partly dried.	...do....	Leaf drying.....	...do....	Leaf almost dead, no new pustules.
6	Mar. 13	Mar. 13	Several pustules at base of one leaf.	Mar. 19	No further development of rust.	Mar. 25	No further development of rust.
7	...do....	...do....	Unopened pustules at base of one leaf, other leaves flecked.	...do....	Three fresh pustules on leaf; more than 2 per cent of the spores from these pustules germinated in water.	...do....	Three fresh pustules on leaf, and several fresh pustules on leaves which were flecked.
8	...do....	...do....	Unopened pustules on many leaves.	...do....	Two open pustules on one leaf.	...do....	Fresh open pustules on many leaves.
9	...do....	...do....	One pustule on each side of one leaf near tip.	...do....	No further development of rust.	...do....	No further development of rust.
10	...do....	...do....	Leaves with several unopened pustules.	...do....	...do.....	...do....	Do.

It is seen that some of the plants brought in on January 19 and March 12, notably Nos. 1, 3, 4, 7, and 8, continued to produce uredospores. At Arlington, in 1908, fresh rust pustules on new growth of timothy were common after March 15. Undoubtedly the old rust mycelium living in the plants had produced these pustules. Spores collected on January 20 and March 13, 1908, were found to be viable.

Similar conditions undoubtedly prevail in other localities of the same latitude and similar climate where this rust is found. How the rust winters farther north has not been determined, but in the light of recent investigations¹ it is very probable that it lives through the winter in the uredo stage much farther north than the latitude cited. As shown by specimens sent to the Office of Grain Investigations, it seems that teleutospores of this rust are more abundant in northern latitudes than at the Arlington Experimental Farm, where they were very scarce in 1907 and 1908. At the latter place the parasite *Darluca filum* (Biv.) Cast. largely prevents the formation of the teleuto stage, as almost every pustule ready to produce teleutospores is attacked by this fungus and further development is prevented. However, as the æcidial stage, if present, is undoubtedly rare in this country, the teleuto stage is of doubtful importance in the wintering and dissemination of the rust.

METHODS OF DISTRIBUTION OF TIMOTHY RUST.

The rapid distribution of timothy rust in recent years is doubtless due to the dissemination of the uredospore by the usual agencies. Insects have been shown to be carriers of spores,² birds and other animals may carry them from place to place, they may be transferred from one region to another by man through the shipment of rusted timothy hay, etc., but most important is the agency of the wind. It has been shown probable³ that the uredospores of rusts are distributed by the wind not only from field to field, but, rising into the upper air, are carried by currents for hundreds of miles. With a quantity of uredospores on hand in various localities early in the spring, their distribution thus becomes an easy matter and the general dissemination of rust over large areas is accounted for. Undoubtedly, in the course of a few years, the distribution of this rust is to be expected over all timothy-growing sections where conditions are favorable for its development.

With the ultimate dissemination of rust over the greater part of the timothy area a practical certainty, methods of preventing any

¹ Freeman and Johnson, loc. cit.

² Johnson, Edward C. Floret Sterility of Wheats in the Southwest. *Phytopathology*, vol. 1, 1911, p. 18.

³ Freeman and Johnson, loc. cit.; and Klebahn, H., *Die wirtswechselnden Rostpilze*, 1904, pp. 68-72.

considerable damage to the timothy crop from this parasite become necessary. Only one method at present known can be employed against it with any promise of success, and that is the development of varieties of timothy resistant to rust. To this end work has been commenced.

RESISTANCE OF VARIETIES OF TIMOTHY TO RUST.

A fair opportunity was offered to study the resistance of varieties of timothy to rust and to make selections for rust resistance at the Arlington Experimental Farm during 1908 and 1909, as the disease was plentiful in those years. Mr. W. J. Morse, of the Office of Forage-Crop Investigations, who had charge of timothy-breeding work at that place, says in an unpublished report:

By July 30 (1908) no timothies were found to be entirely free from rust. * * * The rust resistance varied greatly, ranging from zero to 98 per cent. In some instances a few small rust spots appeared on the culms and no rust on the leaves. Several selections made no growth at all, the rust appearing to stunt the growth. In other instances the plants made some growth, but the production of seed was prevented. In 1909 the rust attack at the Arlington Experimental Farm was even more severe than in 1908, although the rust did not appear to any extent until the middle of May. This severe attack brought to light the fact that many of the strains marked "resistant" in 1908 appeared to be much less resistant in 1909. It was noticeable, however, that the relative resistance of the different strains was very little different in 1909 from what it was in 1908.

In 1910 the rust attack on the same farm was not nearly so severe as in the two preceding years. Under such conditions the distinction between resistant and nonresistant strains is not nearly as well marked as when rusts are abundant. As a result many strains failed to retain in their resistance percentages the same relative position which they occupied in 1908 and 1909. This corroborates the experience of the writer that the value of rust-resistance figures obtained in years when the rust is not abundant or at places where the rust attacks are not severe is questionable and shows that the notes taken at such times and places may often be misleading. Dependable data can be secured only either in "rust years" or in places where vigorous rust attacks occur or are artificially produced every year.¹

In order to determine whether or not the figures on rust resistance obtained in the field during seasons when rust is abundant are comparable to data secured where different strains are placed under identical conditions and subjected to artificial inoculation, experiments were undertaken in 1909 in the greenhouses at Washington, D. C. Seed of various strains of timothies from the 1908 selections at the Arlington Experimental Farm was planted in 4-inch pots.

¹ Freeman and Johnson, loc. cit.

When the timothy was about 2 inches high, it was thinned to 10 plants or less in a pot and the first leaf of each plant was inoculated by placing on it, by means of a flattened inoculating needle, a small quantity of fresh uredospores. The pots were placed in a moist chamber for 48 hours, as described on page 8 of this paper, and were then removed and allowed to stand for 17 to 21 days, when final notes were taken. The percentage of noninfection from uredospore inoculations of timothy selections and the rust-resistance percentages of these selections in the field during 1908 and 1909 are shown in Table III.

TABLE III.—*The percentage of noninfection from uredospore inoculations of timothy selections and the rust-resistance percentages of these selections in the field during 1908 and 1909.*

Serial No.	Date of inoculation.	Timothy selections.	Leaves inoculated.	Leaves pustuled.	Days of incubation.	Leaves not infected.	Resistance in field.	
							1908	1909
	1909.		Number.	Number.	Number.	Per cent.	Per cent.	Per cent.
1	Jan. 2	965-25	28	10	17	64	98	50
2	do	965-15	18	4	17	77	80	30
3	do	965-22	12	6	17	50	0	(¹)
4	do	952-'04	19	12	17	37	60	-----
5	do	952-'06	5	5	17	0	70	20
6	Jan. 9	965-18	11	6	18	46	60	-----
7	do	29-A	14	4	18	71	98	-----
8	do	45-B	14	9	18	36	90	30
9	do	967-16	11	1	18	91	0	(¹)
10	Jan. 15	52-B	16	13	18	19	0	-----
11	do	50-B	14	13	18	7	90	40
12	Jan. 20	965-'03	8	8	21	0	98	40
13	do	967-16	8	6	21	25	0	(¹)
14	do	967-15	13	11	21	16	90	40
15	do	16	8	6	21	25	70	-----
16	do	967-35	7	6	21	14	0	10
17	do	49	18	15	21	17	98	40
18	do	75-C	17	17	21	0	0	(¹)
19	do	43-A	19	15	21	21	60	10
20	do	81	6	6	21	0	60	70
21	do	45-A	11	9	21	18	90	40
22	do	37-A	18	12	21	34	75	-----
23	Jan. 23	49-A	14	7	18	50	60	20
24	do	952-'06	8	3	18	63	70	20

¹ Discarded.

The percentages of inoculated leaves which did not develop rust do not correspond with the rust-resistance figures obtained in the field. This is accounted for by the fact that even the most rust-resistant varieties of both grasses and cereals will develop rust to some extent when carefully inoculated in the greenhouse with the rust most common on the respective hosts. It is always noticeable, however, that although every inoculated leaf of a rust-resistant strain may be affected, the rust infection is much less severe on them than on susceptible varieties. Therefore in making observations on rust resistance not only the percentage of leaves developing rust pustules but also the severity of the infection must be considered. Although such observations are not noted in Table III it was found that, in so far as

the vigor of the infection was concerned, the relative rust resistance of strains as obtained in the field was fairly well maintained in the greenhouse experiments and that the differences in resistant and susceptible strains were marked.

Having determined, then, that there are wide differences in timothy strains with regard to resistance and susceptibility to rust, the problem in timothy-rust prevention is one of breeding. This may not be as difficult as it appears at first, since up to the present time timothies have not been highly bred and there are not only great differences between varieties but apparently unusual variations within a variety. Response to selection, therefore, may be both rapid and well marked. Such breeding, however, to be of any value must be carried on in places where the rust is abundant or where either naturally or artificially a rust attack occurs every year.

SUMMARY.

Timothy rust was reported in the United States as early as 1882. It was reported from Iowa in 1891. From 1891 to 1906 no mention of the parasite has been found. In 1906 the rust became epidemic at the Arlington Experimental Farm, near Washington, D. C., and since then has been found to be widespread, having been reported from Maine to Ontario and northern Minnesota and south to Iowa, Kentucky, and Virginia.

Timothy rust is similar in general appearance and morphological characteristics to *Puccinia graminis* Pers. on wheat.

Inoculation experiments with timothy rust at Washington, D. C., show that it can be transferred easily to various grasses. Similar results have been obtained by Eriksson in Europe. This demonstrates that the rust in the United States and the rust in Europe are identical. That it is not a well-fixed species is substantiated. By using bridging hosts timothy rust can be made to transfer to various cereals which it will not attack directly. That such transfers take place in nature to some extent is probable.

The æcidial stage of this rust is not definitely known. Eriksson and Henning in numerous inoculations with the teleutospores on barberries obtained negative results except in one instance. On this basis they consider the rust a distinct species, naming it *Puccinia phlei-pratensis*. Kern has observed several unsuccessful inoculations on the barberry in this country. From the one apparently positive result of Eriksson and Henning, however, he believes that the rust is not entitled to specific rank and should be included under *Puccinia graminis* Pers. Evans accepts the name *Puccinia phlei-pratensis* and shows that there are well-marked differences in the details of the infection from the uredospore of this rust and the *graminis* form on

cereals. From the physiological specialization of the rust, from its distinct method of uredospore infection, from the numerous negative results of inoculations with the teleutospore on barberries, and from the delicacy of the uredo mycelium, as compared with typical *graminis* forms, it is evident that this rust has many distinctive characteristics. Unless further experiments should show that the rust can produce its æcidium on the barberry and until such experiments have been performed, the writer favors the use of the specific name *Puccinia phleipratensis* Erikss. and Henn.

At the Arlington Experimental Farm the rust mycelium lives through the winter. It is very probable that it lives over winter in the uredo stage much farther north than the latitude cited. As the æcidial stage, if present, is undoubtedly rare in the United States the teleuto stage is of doubtful importance in the wintering and dissemination of the rust.

The rapid distribution of timothy rust in recent years is undoubtedly due to the dissemination of the uredospores by the usual agencies, namely, insects, birds, animals, man, surface winds, and upper air currents. Its ultimate distribution over all timothy-growing sections favorable to it is to be expected, and methods of preventing any considerable damage to the timothy crop become necessary.

In a study of the resistance of varieties of timothy to rust in 1908 and 1909, W. J. Morse found that the resistance "varied greatly, ranging from zero to 98 per cent." The resistance of different strains relative to each other varied little during the two years. Under a less severe rust attack in 1910 these strains in many instances failed to retain the same relative position as in previous years. This tends to show that dependable data can be obtained only when vigorous rust attacks occur.

In greenhouse experiments where strains which had been tested in the field were subjected to similar inoculation and identical conditions during the period of incubation, the percentage of inoculated leaves which did not become infected did not correspond with the figures on rust resistance obtained in the field. When the severity of infection and not the percentage of leaves developing pustules was considered, however, the relative resistance of strains as obtained in the field was fairly well maintained in the greenhouse.

As there are wide differences in timothy strains with regard to rust resistance, the problem in timothy-rust prevention becomes one of breeding. This may not be as difficult as it appears at first. Such work, however, to be of value must be carried on when the rust is abundant and where either naturally or artificially a rust attack occurs every year.

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BUREAU OF PLANT INDUSTRY—BULLETIN NO. 225.

B. T. GALLOWAY, *Chief of Bureau.*

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A SPOT DISEASE OF CAULIFLOWER.

BY

LUCIA McCULLOCH,

Scientific Assistant, Laboratory of Plant Pathology.

ISSUED AUGUST 29, 1911.



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LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., May 31, 1911.

SIR: I have the honor to transmit herewith a manuscript entitled "A Spot Disease of Cauliflower," by Miss Lucia McCulloch, scientific assistant in the Laboratory of Plant Pathology, and recommend its publication as Bulletin No. 225 of the series of this bureau.

This paper deals with a disease which is shown to be of bacterial origin and which has not been reported hitherto.

The investigations of this disease have been carried out according to the advice and suggestions of Dr. Erwin F. Smith.

Respectfully,

WM. A. TAYLOR,
Acting Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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6

A SPOT DISEASE OF CAULIFLOWER.

INTRODUCTION.

In April and again in May, 1909, diseased cauliflower plants were sent to the Laboratory of Plant Pathology from a farm in southeastern Virginia. In both lots the leaves were closely covered with brownish to purplish gray spots 1 to 3 millimeters in diameter (Pl. I). There were also larger diseased areas due to the coalescing of spots. All parts of the leaves were affected. Where the midribs and veins were badly attacked the tissues had contracted, giving a puckered appearance to the leaves (Pl. II). From the spots a bacterium was secured in pure cultures by means of petri-dish poured plates on agar, and subcultures from colonies thus obtained were used for inoculating healthy cauliflower plants.

The cauliflower heads from the same plants were not in good condition, but no success attended the efforts to secure from them the same kind of bacterium that was found in the leaf spots.

What appears to be the same disease was also received once on cauliflower from Florida.

INOCULATIONS.

All inoculations were made by spraying the plants with pure cultures of the bacterium suspended in water (24 to 48 hour agar slants washed off in sterile water). Young, healthy cauliflower plants 6 to 10 inches high were used, some being kept in infection cages and some merely on a bench in the greenhouse.

The infection shows first on the lower surface of the leaves as sunken water-soaked spots.¹ These are visible on the third day after inoculation. In 4 or 5 days the spots are dark purplish-gray and show on both surfaces. In transmitted light the centers are thin, almost colorless, and surrounded by a dark border. In size they vary from mere points to spots 1.5 millimeters in diameter. In shape they are irregularly angled; the spread of the disease appears to be stopped or hindered by the veins of the leaf. The individual

¹ Some infections from old cultures that had probably lost much of their virulence were first indicated after 6 to 8 days by tiny water-soaked elevations. As the disease progressed the tissues collapsed and a sunken spot resulted.

spots do not become more than 2 to 3 millimeters in largest diameter, though where crowded the spots usually coalesce, forming diseased areas of considerable size.

When only the upper surface of leaves was subjected to the inoculating spray very few infections resulted, while inoculations on the lower surface gave numerous infections (Pl. III). So far as observed in sections the infection takes place only through stomata, and mostly from the lower surface. The older and the very young leaves appear to be partially or even completely immune, while those of intermediate age (on the same plant) may be seriously affected.

The diseased leaves become yellow and fall off in from three to five weeks. The younger leaves and new growth are healthy. Under our rather dry hothouse conditions in no case was there evidence of infection on any but the inoculated leaves.

From spots developing on leaves inoculated with the original culture the organism was repeatedly isolated by means of petri-dish poured plates, and subcultures from colonies were again used for inoculations, always with the production of the characteristic infection.

The checks in all cases remained healthy; also numerous other cauliflower plants in the same greenhouse.

Cabbages inoculated with this organism became infected in the same manner as the cauliflower with one exception, viz, the spots were darker. From spots appearing on the inoculated cabbages the organism was isolated and tested on cauliflower, with the result of the production of the disease.

During May and June of 1909 all inoculations resulted in successful and typical infections.

On July 10, 1909, seven plants were inoculated in the usual manner and, contrary to expectations, no infections resulted. The conditions were the same as in previous inoculations, except that the temperature was higher at this time, 26° to 34° C. (78° to 93° F.). Subsequent experiments show that the bacterium causing the disease refuses to grow in artificial media at 29° C. (84° F.) or above. It is probable, therefore, that in this case the high temperature prevented infection.

After July no more plants were available for inoculation until January 24, 1910, when 10 plants were inoculated. No infections resulted. On February 2, 1910, 10 more plants were inoculated and no infections resulted. All conditions seemed favorable, and loss of virulence in the culture was suspected as the cause of failure to infect. The cultures used for inoculation were descended through numerous transfers made during the winter. An agar-stock culture which had not been transferred since September, 1909, was then tried. Fresh agar-slant cultures were made from the September stock and used

when 24 hours old (February 12, 1910) for inoculating cauliflower plants. This time infections resulted. The infections were very slight, however, and the spots too few in number to cause any noticeable injury to the plants, but the bacteria plated from these spots produced typical colonies on agar and characteristic growth in artificial media. Cauliflower plants inoculated with this new strain became very generally infected, which fact seems to indicate that the organism had increased in virulence by passage through the host.

On December 6, 1910, cabbage, cauliflower, turnip, rutabaga, radish, and mustard were inoculated in cages by spraying with sterile water to which had been added agar-streak cultures 3 days old. All of these plants were young. There were two to four of each sort. The material for inoculation was obtained from a cauliflower inoculated November 22, 1910. Infections were obtained on cabbage and cauliflower (six days), but not on the other plants. Sections of the spots made on the tenth day showed them to be full of bacteria.

On March 4, 1911, three cauliflower plants were again inoculated by spraying with sterile water to which had been added 2-day-old agar-slant cultures. These plants were about 8 inches high and very healthy. They were kept in an infection cage for two days. At the end of 10 days there were very small dark specks on each of the plants. These specks were in the center of a small semitransparent elevation. A microscopic examination showed bacteria present in these spots. The flower stalks of plant 104 also showed elongated water-soaked spots, darker in the center. These also contained bacteria and plates made from them yielded the organism in pure culture. The flowering part of plant 104 bore no spots, although it had been drenched with the spray. The check plant remained healthy.

Several attempts to inoculate the heads of the cauliflower gave no satisfactory results. Growing heads were copiously inoculated and kept under moist conditions, but no infections occurred. Infection spots similar to those on leafstalks and midribs occurred on some of the larger stalks of the flower head, while the flowering parts remained free from infection. Mature heads from the market were also inoculated, but as decay of the tender surface was general in the checks as well as in the inoculated heads, the results are not conclusive.

DESCRIPTION OF THE CAULIFLOWER LEAF-SPOT ORGANISM.

MORPHOLOGY.

The organism is a short rod, forming long chains in some media. Ends rounded. Size from leaf 1.5 to 2.4 μ by 0.8 to 0.9 μ . Size in 24-hour beef-agar culture, temperature 20° to 25° C., 1.5 to 3 μ by 0.9 μ . No spores are produced. The organism is actively motile by

means of one to five polar flagella, which are two to three times the length of the rod. (Stained by Van Ermengem's method; also by Hugh Williams's method.) Motility occurs in most artificial media. In beef-bouillon cultures grown and kept at 0.5° to 1.5° C. for four months the organism is still motile. Involution forms were found in alkaline beef bouillon (—17 on Fuller's scale). Pseudozoogloes occur in Uschinsky's solution and in acid beef bouillon.

REACTION TO STAINS.

The organism does not stain by Gram. Modified Gram, using amyl alcohol, gives a deep blue stain. It stains readily and strongly with carbol fuchsin, with an alcoholic solution of gentian violet, and with a stain obtained from Dr. Kinyoun which contains methylene blue, silver nitrate, azure I, and azure II. It is not acid fast.

CULTURAL CHARACTERS.

Agar plates (+15 peptonized beef bouillon with 1 per cent agar).—The colonies are visible on the second day as tiny white specks (temperature 23° C.).

In three to four days the colonies are 1 to 3 millimeters in diameter, white (opalescent in transmitted light), round, smooth, flat, shining, and translucent, with edges entire. Structure, under hand lens, coarsely granular with internal reticulations. Buried colonies small, lens shaped. With age the colonies become dull to dirty white, slightly irregular in shape, the edges undulate, slightly crinkled, and with indistinct radiating marginal lines. The internal reticulations disappear and the coarsely granular appearance changes to finely granular. In thinly sown plates 7-day-old colonies are 6 to 8 millimeters in diameter; 15-day-old colonies are 12 to 15 millimeters in diameter.

Agar stabs.—The surface of the agar is covered in two days (22° to 24° C.) by a thin white growth. For several days the stab shows a moderate growth in the upper 8 to 10 millimeters, but this does not continue. Finally, the stab is almost, if not quite, invisible. Crystals appear in the stab and on the surface.

Agar slants.—In smear cultures the surface is covered in two days (temperature 19° to 21° C.) with a thin white growth, glistening, coarsely and irregularly pitted. White sediment in the V.

In streak cultures in two days (temperature 19° to 21° C.) the streak is 3 to 5 millimeters wide, white, margins slightly undulate. The internal reticulations seen in colonies on plates are present in the streak cultures. At right angles to the streak are fine lines extending from center to margin.

Agar cultures become slightly greenish.

Beef bouillon.—Peptonized beef bouillon + 15 held at 24° to 25° C., if inoculated from young, vigorous bouillon cultures, clouds thinly in 6 hours and is moderately to heavily clouded in 24 hours. The growth is best at the surface, where a white layer is formed. This is not a true pellicle, as it disintegrates when the cultures are handled.¹ No zoogloæ are present. There is no rim. In two days there are heavy clouds and a moderate amount of white flocculent precipitate. After several weeks the precipitate is white and slimy, moderate in quantity, and with small crystals in it. The medium becomes slightly greenish. After several months the precipitate is viscid.

Acid bouillon.—In neutral beef bouillon plus vegetable acids, growth occurs until an acidity of +34 for oxalic acid and +36 for malic and citric acids (Fuller's scale) is reached. There is no rim or pellicle. Occasionally pseudozoogloæ are formed in the more acid media.

Microscopic examination shows most of the organisms greatly reduced in length, some so short as to be spheroidal. That these were not contaminations was proved by plating out and by tests on other culture media.

Alkaline bouillon.—In alkaline beef bouillon (NaOH used) the organism grew well in -17, -19, -22, less in -23, and not at all in -25, -26, and -28 (Fuller's scale). Involution forms and filaments were present in -17 beef bouillon when two weeks old.

Bouillon with sodium chlorid.—In beef bouillon plus 2 per cent NaCl the growth is as good as in plain beef bouillon. With the addition of more NaCl the growth gradually lessens until it is scarcely noticeable in a 5 per cent solution. When grown in a 4 per cent solution, the organism is not motile. In a 2 per cent solution the organism is motile, but less so than in beef bouillon without NaCl.

Beef bouillon over chloroform.—For the first 24 hours the growth is somewhat retarded. By the end of 48 hours no difference could be seen between cultures over chloroform (5 c. c. of chloroform with 10 c. c. of beef bouillon not shaken) and those in plain beef bouillon.

Loeffler's blood serum.—Growth of stroke is moderate, smooth, shining; color creamy; margins finely crinkled. No liquefaction. After three months the whole medium was slightly browned.

Cohn's solution.—Moderate clouding and white precipitate; no rim, pellicle, or zoogloæ; no fluorescence. After some weeks feather-like crystals of considerable size (5 to 10 by 2 to 6 mm.) are formed.

Fermi's solution.—Moderate clouding at first. Precipitate moderate to abundant, white, flocculent. Pellicle white, tender, sinking in strings and masses. Finally the medium is densely clouded and

¹ Old cultures kept for several months at 0.5° to 1.5° C. had a delicate pellicle.

pale green-fluorescent (between water green and greenish glaucous, *Repertoire de Couleurs*, Paris, 1905); more precipitate than in beef bouillon.

Nutrient gelatin (+10 on Fuller's scale).—The stab cultures liquefied in 8 to 10 days (temperature 17° to 18° C.). Growth from surface crateriform. Slight, white, granular precipitate. Slight green fluorescence.

The plate cultures showed no signs of growth in 24 hours at 17° to 18° C. In three days well-isolated colonies vary from mere points to round growths 2 millimeters in diameter. The gelatin is liquefied in cuplike hollows. Margin of smaller colonies entire, of larger colonies fimbriate. Thickly sown plates entirely liquefied in two days at 15° to 16° C.

Litmus milk.—The medium becomes dark blue at the surface in 12 to 24 hours. The darkening proceeds downward in definite layers until in 8 to 10 days the whole medium is dark blue with a slight white precipitate. During six months' observation the medium remained dark blue (reflected light) and liquid. Finally by evaporation the medium becomes thickened, but there is at no time any separation into curd and whey.

A few cultures showed a trace of reduction of litmus at the bottom.

Milk.—As in the litmus-milk cultures, growth and color-change in the milk begin at the surface, proceeding downward in definite layers. In 15 to 20 days the whole tube (10 c. c. of milk) is yellow (near Ridgway's Naples yellow, but somewhat duller and with a greenish tinge) and translucent. No separation into curd and whey. Fat not changed. In four months the medium is quite dark (reddish-brown) and somewhat thick (evaporated to about 5 c. c.). Small tyrosin crystals are formed. These are distinctly visible only with a lens.

Uchinsky's solution.—Growth moderate to copious; pellicle white, tender, breaking and sinking easily. Pseudozoogloes are present. There is a greenish fluorescence. The old cultures are much like those in Fermi's solution.

OTHER CHARACTERISTICS.

Fermentation tubes.—The organism is aerobic and does not form gas. It was tested in fermentation tubes in the presence of dextrose, saccharose, lactose, maltose, glycerin, and mannit, each of these carbon compounds being added to a basal solution consisting of 1 per cent of Witte's peptone dissolved in water. It did not grow in the closed end of the fermentation tubes in the presence of any of these substances.

Ammonia production.—Moderate.

Nitrates.—Nitrates are not reduced.

Indol.—Indol production is feeble.

Hydrogen sulphid.—Hydrogen sulphid is not formed in cultures on beef-peptone agar, potato cylinders, turnip cylinders, or in beef bouillon or milk.

TEMPERATURE RELATIONS:

Thermal death point.—The thermal death point is 46° C. The following tests were made: Newly inoculated beef-bouillon (+15) cultures in tubes were suspended in a hot-water bath where they were kept for 10 minutes at a constant temperature, then removed to room temperature (20° to 24° C.). First, temperatures ranging from 40° to 50° C. were tried, and, the thermal death point seeming to lie about halfway between, trials were again made of 45°, 46°, and 47° C. More than half of the cultures exposed to 45° C. for 10 minutes clouded in 3 to 5 days. Of cultures exposed to 46° C. 1 out of 12 clouded after 11 days. The others never clouded. Of 20 cultures exposed to 47° C., none clouded.

Optimum temperature.—The optimum temperature for growth is 24° to 25° C.

Maximum temperature.—The maximum temperature for growth is very low, viz, 29° C.

Minimum temperature.—The minimum temperature for growth is below 0° C.

The organism was dead after exposure for 3½ days at 33° to 36° C. in beef bouillon.

EFFECT OF DESICCATION.

When young, well-clouded beef-bouillon cultures were dried on cover glasses and kept in a dark place at temperatures of 22° to 25° C., 75 per cent were killed in 24 hours and 90 per cent in 48 hours. All were dead in five days.

EFFECT OF SUNLIGHT.

Four minutes' exposure to sunlight killed all organisms in thinly sown agar poured plates exposed bottom up on ice, one-half of each plate being covered as a check.

EFFECT OF FREEZING.

Freezing by means of salt and pounded ice for two and five hours in +15 beef bouillon had no effect in reducing the number or the vitality of the organisms, as shown by poured-plate cultures made before and after freezing.

Beef bouillon (10 c. c.) inoculated and at once frozen and kept at temperatures of -4° to -18° C. (average -12° C.) for nine days

showed no growth during this period, but clouded moderately three days after removal to temperature of 18° to 20° C., and plates from this tube gave pure cultures of the cauliflower organism. Plates poured before and after 10 days' freezing showed considerable reduction in the numbers of organisms, but the growth of the living ones was not retarded. Some tubes of beef bouillon, inoculated with a 3-millimeter loop from a 48-hour bouillon culture and kept frozen for seven days, clouded within 48 hours after removal to a temperature of 18° to 20° C. Another frozen for 22 days did not cloud after removal to temperatures of 18° to 20° C. The check clouded. The organism grows readily at low temperatures, e. g., beef-bouillon cultures clouded in seven days when kept at temperatures of 0° to 1° C.

VITALITY ON CULTURE MEDIA.

This organism remains alive for six to eight months at temperatures varying from 18° to 24° C. on beef agar, Loeffler's blood serum, and potato cylinders, and in peptonized beef bouillon (+15), beef gelatin (+10), milk, Uschinsky's, Fermi's, and Cohn's solutions. Evaporation was not prevented in these cultures and the media became concentrated, often dry, and yet the organism was frequently alive. Beef-agar and beef-gelatin cultures at temperatures of 12° to 15° C. and subject to less evaporation (in refrigerator) were dead after eight months. In media less favorable for the growth of this organism, as beef bouillon plus salt, alkali, or acid, the bacteria live but two to three months.

GROUP NUMBER.

The group number, according to the descriptive chart of the Society of American Bacteriologists, is 211.3332023.

NAME OF ORGANISM.

This organism appears to be an undescribed form, and because of the characteristic spotting of the affected leaves the name *Bacterium maculicolum* (n. sp.) is suggested.

LATIN DIAGNOSIS.

BACTERIUM MACULICOLUM (N. SP.).

Baculis in hospite brevibus, cylindricis, apicibus rotundatis, solitariis, saepe binis (in agar-agar quandoque 10–30 baculis in filamenta conjunctis); baculis 1.5–3.0 μ x 0.8–0.9 μ ; 1–5 flagellis polaribus mobilibus; aerobiis, asporis.

Habitat in foliis vivis Brassicae oleraceae in maculis 1–3 mm. latis, purpureo-griseo colore. Coloniae gelatinam liquefacientes. Coloniae in agar-agar rotundae, albae, nitentes. Si baculi in petri-vasibus rare seruntur, in septimo die colonae 6–8 mm. diam. sunt. Baculi

methodo Gram non colorantur. Nitrum non redigitur. Lac sterile alcalinum fit; initio translucidum, flavum pallidum demum opacum, brunnen et gelatum; casein non segregatur. Inter temperaturam 29° C. et temperaturam -5° C. culturae crescunt. Si culturae novae in infusione carnis $\frac{1}{4}$ horam in temperatura 46° C. tenentur, moriuntur. Inter temperaturas -5° C. et -15° C. per decem dies non moriuntur. Si baculi siccantur vel soli exponuntur, celeriter moriuntur. In foliis vivis Brassicae oleraceae aspergendo inoculatis, maculae in 3-4 diebus producuntur. Contagium in stomatibus fit.

SUMMARY.

The leaf-spot disease of cauliflower described in the preceding pages is due to a bacterial organism, which was secured in pure culture from the leaf spots and inoculated into healthy cauliflower plants, with production of the disease. Healthy cabbages inoculated with the organism also showed similar infection.

Inoculations during July, 1909, were unsuccessful because of the higher temperature.

The heads of cauliflower gave no satisfactory results when inoculated with the organism.

The name *Bacterium maculicolum* has been suggested for this organism. It is a schizomycete, pathogenic to crucifers, causing numerous small spots on cauliflower and cabbage. Entrance by way of the stomata. Organism white, but causing a greenish fluorescence in some media (beef bouillon +15, beef gelatin +10, beef agar +15, Uschinsky and Fermi). Motile by means of one to several polar flagella. A short rod (1.5 to 3 μ by 0.9 μ), single or in chains in some media (10 to 30 μ long on agar; 10 to 24 μ long in beef bouillon plus 4 per cent sodium chlorid). Does not stain by Gram; stains deeply with amyl Gram.

No spores. Involution forms (found in alkaline beef bouillon) and pseudozoogloesæ. Aerobic. Liquefies gelatin slowly. Does not liquefy Loeffler's blood serum. Not gas forming. Feeble production of ammonia, indol, and hydrogen sulphid. Nitrates not reduced. Tolerates acids, citric and malic to +36 and oxalic to +34 (Fuller's scale). Tolerates sodium hydroxid in beef bouillon to -25 (Fuller's scale).

Optimum temperature 24° to 25° C. Thermal death point 46° C. Will not grow in beef bouillon (+15) or on agar (+15) at 29° C. Grows at 0° C. and below. Grows well in bouillon over chloroform. Grows in Cohn's solution. Blues litmus milk.

The most striking facts about the organism are its ability to grow at temperatures below freezing and its failure to grow at a common summer temperature (85° F.).

The leaves of the attacked plants fall off.



UPPER SURFACES OF CAULIFLOWER LEAVES FROM VIRGINIA, SHOWING NATURAL INFECTION WITH *BACTERIUM MACULICOLUM*. PHOTOGRAPHED MAY 4, 1909.

1701



UNDER SURFACES OF CAULIFLOWER LEAVES FROM VIRGINIA, SHOWING MIDRIBS SPOTTED BY NATURAL INFECTION WITH *BACTERIUM MACULICOLUM*. PHOTOGRAPHED MAY 4, 1909.

U of M

Mr. U



UNDER SURFACES OF CAULIFLOWER LEAVES FROM HOTHOUSE; INOCULATED BY SPRAYING ON MAY 19, 1909, WITH BACTERIUM MACULICOLUM. PHOTOGRAPHED JUNE 2, 1909.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 226.

B. T. GALLOWAY, *Chief of Bureau.*

A PLANT-DISEASE SURVEY IN THE VICINITY OF SAN ANTONIO, TEXAS.

BY

FREDERICK D. HEALD AND FREDERICK A. WOLF,

Experts.

ISSUED JANUARY 24, 1912.



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COTTON AND TRUCK-CROP DISEASES AND SUGAR-PLANT INVESTIGATIONS.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., June 5, 1911.

SIR: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 226 of the Bureau series the accompanying manuscript entitled "A Plant Disease Survey in the Vicinity of San Antonio, Texas," submitted with a view to publication by Mr. W. A. Orton, Pathologist in Charge of Cotton and Truck-Crop Diseases and Sugar-Plant Investigations.

This bulletin gives the results of work done by the authors, Dr. Frederick D. Heald, professor of botany, University of Texas, and Mr. Frederick A. Wolf, tutor in botany, University of Texas. The work was undertaken at the request of Mr. C. S. Scofield, Agriculturist in Charge of Western Agricultural Extension, who desired a preliminary survey of the plant diseases of this region to be made as a part of the work of the San Antonio Experiment Farm.

Respectfully,

WM. A. TAYLOR,
Acting Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

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A PLANT-DISEASE SURVEY IN THE VICINITY OF SAN ANTONIO, TEXAS.

INTRODUCTION.

During the summer and fall of 1909 and the winter and spring of 1910 a plant-disease survey was made of a portion of Texas in the vicinity of San Antonio. The object of this work was to determine the diseases which were prevalent with a view to a later and more detailed investigation of those which are either new or imperfectly known.

The emphasis has been placed upon the diseases of plants due to bacteria, fungi, or other parasites, but environmental factors have not been overlooked. The field is an exceedingly fruitful one, since but little has been published concerning the parasitic fungi or plant diseases of this part of the country. Besides the report of Jennings (34),¹ issued some years ago, and a short list by Cooke (9), but few scattered records of Texas fungi exist. It will not be surprising, then, if a detailed examination of a restricted area should show many new and interesting forms.

The work outlined in this report was carried out by the writers, with headquarters at the University of Texas. Acknowledgment is here made of the helpful suggestions of Mr. W. A. Orton. Mrs. F. W. Patterson, and Miss E. C. Field, of the Department, have very kindly assisted in working over the doubtful specimens and in the determination of most species which appeared to be new, with the exception of the Uredinales, which were submitted to Mr. F. D. Kern, Lafayette, Ind. Several specimens were also referred to Prof. C. H. Peck, Albany, N. Y. In addition, the senior writer visited the herbaria at Washington and the New York Botanical Garden in order to compare our material with their collections which are rich in type specimens.

Specimens have been deposited in the herbarium of the University of Texas, at Austin, while duplicates, including type specimens,

¹ The serial numbers in parentheses used in this bulletin refer to the index to literature, pp. 107-108.

have been placed in the herbarium of pathological collections, Bureau of Plant Industry, Washington, D. C. New species have been described as such in different numbers of *Mycologia*.

TERRITORY COVERED BY THE SURVEY.

The territory covered by this survey is included within a circle having a radius of 100 miles from San Antonio. One trip was made to the south of this region, and collections were made at Falfurrias and Alice, outside of the territory described. The accompanying map (fig. 1) shows the territory studied, and all of the points at which collections were made are indicated by name and solid black circle. It will be observed that more attention was paid to the eastern and southeastern portions of the territory than elsewhere. The explanation for this will be evident by reference to the discussion of crops, native vegetation, and topography of the region.

PHYSIOGRAPHY AND SOILS.

The region studied occupies the coastal plain of Texas in the south and east and extends into the Edwards Plateau and Llano country in the northwest. It is traversed diagonally, beginning in the northern part, by the Colorado, Guadalupe, San Antonio, Medina, Frio, and Nueces Rivers, most of which rise in the edge of the Edwards Plateau and cross the coastal plain to the gulf. A gradual rise characterizes the elevation from the low coastal prairie in the southeast to the rough mountain country of the Edwards Plateau in the northwest. Table I shows the elevations for different stations.

TABLE I.—*Elevation for principal stations.*

Less than 250 feet.	250 to 500 feet.	500 to 1,000 feet.	Over 1,000 feet.
Beeville, 225. Cuero, 177. Hallettsville, 235. Victoria, 187.	Flatonia, 465. Gonzales, 299. Luling, 418. Runge, 308.	Austin, 593. Georgetown, 750. Hondo, 901. New Braunfels, 720. Sabinal, 964. San Antonio, 701. San Marcos, 588. Uvalde, 987.	Blanco, 1,350. Boerne, 1,412. Fredericksburg, 1,742. Kerrville, 1,660. Llano, 1,040.

The region under consideration includes part of the three units of the coastal plain. In the extreme southeastern portion, in Victoria, Goliad, and Bee Counties, may be found the interior border of the coast prairie region, which is flat, low lying, and generally treeless, with the exception of the river valleys. In parts of this area the

mesquite and other timber is encroaching upon the prairies where its natural spread is not held in check by agricultural development.

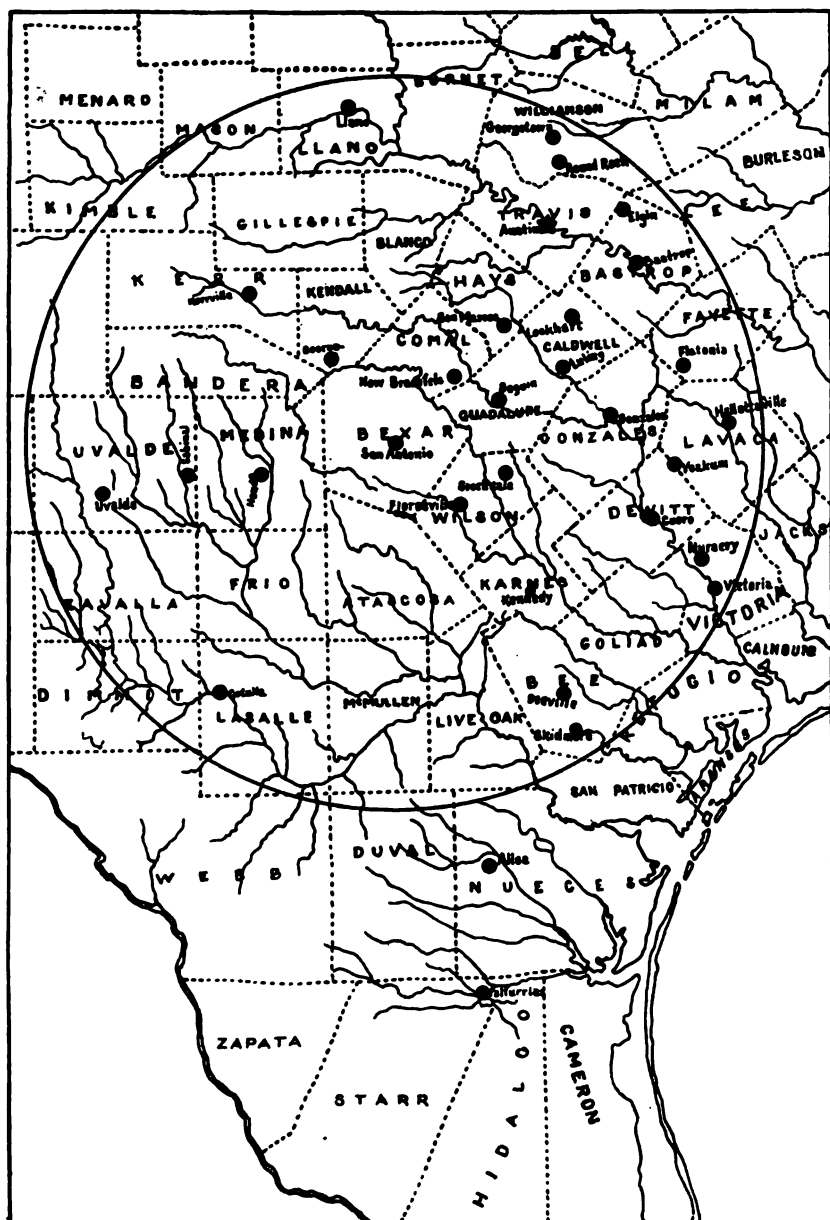


FIG. 1.—Map of a part of the State of Texas, showing the territory covered and places visited in connection with the plant-disease survey.

The prevailing soils in this area except in the bottom lands are stiff, waxy clays, generally with an impervious clay subsoil, and

ranging in color from black to chocolate. They are of residual origin.

The coast prairie region is succeeded by the Tertiary forested area, which extends from Bastrop County in the northeast to the southwest. It includes a considerable part of the post-oak lands of the lignitic belt. The region is much more hilly than the coast prairies, and the rise in elevation is gradual. The southern portion is level or only slightly rolling and less forested than the more hilly northern part.

The soils in this area are mainly residual, varying according to the character of the underlying formation. In various localities may be found sands and sandy loams well adapted to truck crops, as in portions of Bastrop, Caldwell, Gonzales, and Wilson Counties. Clays and clay loams may also be found, while rich alluvial soils occur along the river valleys.

A narrow extension of the rich Cretaceous prairies of northern Texas extends southward through Williamson, eastern Travis, Hays, Comal, and Bexar Counties. The typical soil is black and waxy, derived from the underlying Cretaceous chinks, clays, and marls. The land is exceedingly fertile and produces good yields of cotton and corn when there is sufficient rainfall.

The region investigated includes a small part of the Llano country, in the northwest along the Colorado and Llano Rivers and north of the Edwards Plateau. The region is rough and hilly, with low mountains, the elevations ranging from 1,000 to 1,800 feet. The underlying rocks are largely granite. In many places they are sparsely covered with soil, but the valleys in many localities have fertile soils suitable for the culture of a variety of crops.

The northwestern portion of the region south of the Llano country is occupied by the southern extension of the Edwards Plateau. The region extends west and northwest from the Balcones escarpment, a line of cliffs or hills which terminate abruptly just west and north of a line connecting Austin, San Antonio, and Uvalde. In contrast to the Llano country, the region is essentially a limestone country and is rough and rugged, being cut by the rivers which have their source in this region. The rivers which cross the area under investigation either originate in the Edwards Plateau or rise at the base of the escarpment. The Edwards Plateau is poorly adapted to agriculture, since it is a rugged, hilly country, with scant soil in many places and a rainfall which ranges from 20 to 25 inches.

CLIMATOLOGY.

RAINFALL.

The rainfall of the territory under investigation decreases progressively from the eastern border to the northwest and southwest, reaching the lowest limit in the southwest. The average annual rainfall in Lavaca County in the extreme eastern portion of the section is more than 30 inches, while at Llano, in the low mountain country in the northwest, the average annual rainfall is only about 22 inches. In the extreme southwestern portion some localities report as low an average as 20 inches or somewhat less.

TABLE II.—*Annual precipitation for 1909 in the region of San Antonio, Tex.*

Stations.	Total precipitation.	Departure from normal.	Stations.	Total precipitation.	Departure from normal.
	<i>Inches.</i>	<i>Inches.</i>		<i>Inches.</i>	<i>Inches.</i>
Austin.....	20.57	-13.78	Kerrville.....	26.02	- 3.53
Beeville.....	30.81	+ 1.25	Luling.....	21.26	- 7.63
Blanco.....	24.13	- 5.31	Marble Falls.....	21.14	.....
Boerne.....	25.76	- 6.11	New Braunfels.....	19.66	-10.45
Cuero.....	23.43	-10.66	Rossville.....	16.59	.....
Falfurrias.....	25.42	.....	Runge.....	18.94	-11.29
Flatonia.....	28.42	.....	Sabinal.....	19.34	.....
Fredericksburg.....	21.86	- 6.52	San Antonio.....	14.92	-11.91
Georgetown.....	19.68	-15.79	San Marcos.....	29.81	- 1.51
Gonzales.....	24.53	.....	Taylor.....	20.72	-14.75
Hallettsville.....	31.93	- 1.22	Uvalde.....	18.19	.....
Hondo.....	17.54	-10.63	Victoria.....	33.58	- 2.96

Table II shows that the total rainfall for the year varied from 14.92 inches at San Antonio to 33.58 inches at Victoria. All stations except Beeville show less rainfall than normal, the departure varying from about 4 to 15 inches in the greater portion of the territory.

For the year 1909 only a narrow strip of territory about 25 miles in width, occupying the extreme southeastern portion, had a rainfall slightly over 30 inches. (See fig. 2.) The greater part of the territory north of Bexar County had a rainfall of 20 to 30 inches, while a strip 25 or 30 miles wide lying just west of the more humid southeastern portion had a rainfall similar to the northern half. In a small area at the extreme north in Williamson County the rainfall was only 10 to 20 inches. The extreme west and the entire southwest had a rainfall of 10 to 20 inches with the exception of a small part of Zavalla and Dimmit Counties, where it dropped to less than 10 inches. From the above it may be seen that about one-half of the entire area had a total annual precipitation ranging from 10 to 20 inches.

TABLE III.—*Maximum, minimum, and mean temperatures for 1909 in the region of San Antonio, Tex.*

Station.	Maximum.		Minimum.		Mean.
	Date.	Temperature.	Date.	Temperature.	
		[°] F.		[°] F.	[°] F.
Austin.....	Aug. 19	102	Jan. 11	19	67.9
Beeville.....	..do....	106	..do....	23	72.0
Blanco.....	Aug. 18	107	Jan. 12	14	66.1
Boerne.....	Aug. 19	109	Feb. 16	14	67.5
Cuero.....	Aug. 20	109	Jan. 12	21	71.2
Falfurrias.....	Aug. 18	107	Feb. 16	23	74.1
Flatonia.....	..do....	107	Jan. 12	18	70.5
Fredericksburg.....	..do....	104	..do....	11	66.8
Georgetown.....	..do....	112	..do....	16	67.4
Hallettsville.....	Aug. 20	104	Jan. 11	20	71.0
Hondo.....	Aug. 18	108			
Kerrville.....	Aug. 19	105	Feb. 16	11	66.6
Luling.....	Aug. 18	105	Jan. 12		
New Braunfels.....	Aug. 19	105	Feb. 15	19	69.5
Rossville.....	..do....	108	Jan. 12	19	69.5
Sabinal.....	Aug. 4	110	Dec. 19	20	72.1
San Antonio.....	Aug. 20	107	Jan. 12	20	70.3
San Marcos.....	Aug. 18	105	..do....	19	68.4
Taylor.....	..do....	109	Feb. 15	15	68.0
Uvalde.....	..do....	110	Jan. 12	15	68.0
Victoria.....	..do....	110	Jan. 13	21	71.6
		101	Feb. 16	22	71.0

The month of August was marked by excessive heat, some localities showing a temperature as high as 110° to 112° F. The continuance of the high temperature for several days following or subsequent to the maximum recorded was general for the entire territory. The continued high temperatures and the lack of the customary amount of rainfall caused a very considerable decrease in crop yields. Throughout the area cotton did not make half a crop, many fields of corn were a total failure, and other vegetation suffered in a corresponding degree.

EVAPORATION.

The relative total evaporation for the vicinity of San Antonio is high, with a rate between that of a desert center and a deciduous forest.

Table IV shows the average daily evaporation in inches for the year 1909, and the first three months in 1910, at the San Antonio Experiment Farm. The data were obtained from Mr. C. S. Scofield, who recorded the daily evaporation from an open-air tank.

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TABLE IV.—Average daily evaporation at San Antonio Experiment Farm.

Month.	Evapora- tion.	Average for—	Month.	Evapora- tion.	Average for—
1909.	Inch.		1909.	Inch.	
January.....	0.103	Entire month.	October.....	0.182	Entire month.
February.....	.149	Do.	November.....	.127	Do.
March.....	.188	Do.	December.....	.092	Do.
April.....	.235	26 days. ¹	1910.		
May.....	.237	Entire month.	January.....	.090	First 24 days.
June.....	.331	First 27 days.	February.....	.103	Last 26 days.
July.....	.357	Last 25 days.	March.....	.191	Entire month.
August.....	.274	First 30 days.			
September.....	.241	Entire month.			

¹ No records for Apr. 17, 18, 19, 20.

CROPS AND NATIVE VEGETATION.

The climatological character of the San Antonio area excludes certain crops which are extensively grown in more northern localities and in regions of greater rainfall, but makes possible the culture of some crops which are characteristic of semitropical conditions.

FRUITS.

Apple orchards conducted on a commercial scale are excluded. In a few localities small numbers of trees are to be found in family orchards which generally appear to be seriously affected with black-rot. In the sheltered valleys in the low mountain country to the northwest the most favorable conditions for the growth of apples are found. Several nurseries in the territory grow large quantities of apple stock for shipment to old Mexico, Arizona, and the Pecos country in Texas. The young trees in the nursery were unusually exempt from diseases.

Pears are more successfully grown than apples, but commercial orchards are rare. Most of the small pear orchards have been very seriously neglected, and it is not surprising to find them affected with such diseases as black-rot and bitter-rot. With proper care and cultivation pears could be more extensively grown, since they are much freer from fire-blight than in the more humid coast country.

Peaches are common in the eastern half of the territory and are grown to some extent in the sheltered valleys to the west and northwest. The crop for 1909, however, was a complete failure, owing to the severe freezes of the previous winter. The sudden drops in temperature following warm periods which had started vegetative activity killed many peach trees. This condition will explain the rarity of such diseases as brown-rot and peach freckle (*Cladosporium carpophilum*), which are very abundant when there is an average crop. The entire absence of the peach leaf-curl which is so common farther north may be noted. Present records give only a single

instance of this disease in Texas, and that from the northern part of the State (34). The die-back appears to be the most serious disease.

Apricots are grown to some extent where peaches are found, but are rather rare. Plums are not uncommon, but they are grown less than peaches. The crop for 1909 was a failure, and this will explain why the common brown-rot is not reported. The failure of the crop is not, however, the explanation for the absence of "plum pockets," since this disease appears to be absent during normal seasons. Black-knot was not found in any of the localities visited, either on wild or cultivated species. No cherries are grown in this territory, and apparently the only portions of the State where they can be successfully grown are the Panhandle country, the Llano Estacado, and portions of the Red River Valley.

Persimmons are not uncommon, especially in the eastern half of the territory. The various Japanese varieties do well, but the limited demand has prevented their extensive planting. Figs are grown throughout the eastern and more humid portion of the region, although more favorable conditions are found in the humid coast country extending from Beaumont to Brownsville. In many localities visited the fig trees were killed back to the ground by the severe winter, but they generally sprouted up again from the roots. Most of the trees which were not killed failed to produce fruit on account of the abnormally dry season. In many places the half-ripened fruit dried up on the tree. For this reason no information is at hand concerning the prevalence of fig diseases which attack the fruit. Citrus fruits are grown to a limited extent in the extreme southeastern portion, in Victoria and Bee Counties, while some nurseries farther north are growing large quantities of *Citrus trifoliata* stock which is used for the propagation of the Satsuma orange, the variety most commonly grown. Most of the plantings of citrus varieties are only a few years old (33). The date palm is planted to some extent in the citrus-fruit territory, but none of the trees are more than a few years old.

Grapes are quite generally grown throughout most of the territory, and adapted varieties do well when properly cared for. The black-rot is generally prevalent and is apparently responsible for many of the failures which are attributed to drought. Strawberries can be grown in most of the region in sufficient quantity for home consumption, but the main strawberry region lies to the east in the more humid section. In much of the drier portion of this area the plants die out during the long dry period of the summer unless specially protected or grown under irrigation. Blackberries are grown to some extent, but they are relatively rare as compared with dewberries, which are extensively grown throughout the entire area.

Raspberries, currants, and gooseberries are practically unknown in any part of the area studied.

The pecan is a common nut crop in favorable localities. It is native throughout the area, and many large trees may be found along the fertile valleys of the Llano, Colorado, Guadalupe, and Nueces Rivers. Most of the crop is obtained from the natural growth, but some groves have been planted along the river valleys where the rich, deep soil is adapted to their growth.

TRUCK CROPS.

The main truck-growing section of the State lies farther to the east, in Smith, Cherokee, Anderson, Henderson, Rusk, and Angelina Counties, or in the Brownsville district to the south, but nearly all kinds of truck crops are grown to some extent throughout the territory. In nearly all of the localities west of the ninety-eighth meridian truck crops grown without irrigation are uncertain, and most of the localities in the western half of the region do not supply even a sufficient quantity for home consumption.

The principal truck crops which are grown extensively for shipment to northern markets are potatoes, watermelons, and onions. La Salle County produces large quantities of onions, but Webb County, just to the south and beyond the limits of our area, has a much larger acreage. Watermelons are grown commercially in the sandy soils of Bastrop County and in smaller quantities in many other sections. Most of the home gardens have an abundance of okra and peppers and other common vegetables, such as peas, beans, lettuce, radishes, and eggplants. The Kentucky Wonder bean is grown more extensively than any of the wax-podded varieties, and the black-eyed pea (*Vigna unguiculata*) is common in the vegetable garden, being frequently substituted for the less hardy *Phaseolus* varieties. Cabbage and spinach are grown on a commercial scale in several localities from Austin southward. Spinach is marketed throughout the entire winter even as far north as Austin. The tomato is a common crop in all of the irrigated sections, but produced a light yield during 1909 on account of the excessive heat in the early part of the season, followed by a long period of drought. The greater number of the irrigated truck patches suffered heavy losses from nematodes, and tomatoes were more seriously affected than any other crop. Cucumbers and squashes are quite generally grown, the main varieties of squash being the cushaw and the small bush varieties (cymplings). Asparagus is rare, the only large field observed being at Austin. Its limited culture is apparently due to the lack of demand for this article in the local markets.

FIELD CROPS.

Cotton and corn constitute the main field crops throughout all of the agricultural portion of the region. The western half of the area contains but a small acreage adapted to these crops, and only small yields are obtained even in the more fertile valley lands. In the black-land regions of Williamson County, eastern Travis County, and much of Hays and Comal Counties may be found continuous fields of cotton and corn, with but little land devoted to forage or other crops. Oats is the principal small grain, but wheat is grown to some extent in the more elevated sections of the west and northwest. But little rice is now planted in this area. In recent years the limits of the rice-growing country have been gradually pushed more into the coast region or into the more humid territory to the east.

FORAGE CROPS.

The semiarid conditions which prevail throughout the greater part of the area make the different sorghum varieties the principal crops cultivated for forage. Cane, Kafir corn, and milo maize are extensively grown. In the region surrounding Austin, especially to the north and east, may be found extensive meadows of Johnson grass. Cane and Johnson grass are the most common kinds of hay on the local markets. Alfalfa is grown only to a very limited extent in any portion of the region. In a few localities it is grown without irrigation, but under irrigation it is a very profitable crop, some fields yielding as high as 7 to 8 tons per acre. In some localities in the southern part of the region a number of weedy grasses are cut for hay. Among these may be mentioned *Panicum texanum*, *Echinochloa colona*, and *Eleusine indica*. In some places the weedy grasses grow so abundantly in cornfields that a crop of hay is obtained following the harvesting of the corn. The western half of the area is devoted very largely to stock raising, and many of the 300 species of Texas native and introduced grasses may be found within the territory studied. The most important of the native species are *Bulbilio dactyloides*, *Bouteloua curtipendula*, and various species of *Bouteloua* and *Andropogon*. In certain portions of the more eastern part pastures of Bermuda grass are common, and in some places bur clover (*Medicago arabica*) furnishes valuable winter and early spring forage in the same pastures. Bermuda grass is the only species used extensively for lawns.

NATIVE GROWTH.

The greater portion of the territory lying west of the Colorado and west of a line connecting Austin, San Antonio, and Uvalde is

a part of the low mountain country of the Edwards Plateau. A general idea in regard to the character of the vegetation may be obtained from the following quotation (4) :

Its structure and habits indicate that it is a xerophytic or dry-climate vegetation ; but though this is true of it as a whole, conditions vary enough to give in some places, as in well-watered and sheltered canyons, a relatively luxuriant growth, while in other situations, as upon stony, arid slopes, there is the scantiest vegetation.

One of the most characteristic features of this area is the extensive cedar brakes along the Colorado from Austin to the northwest and along the upper waters of the Llano, Guadalupe, Medina, Nueces, and Frio Rivers.

The greater part of the region lying south of a line connecting Uvalde, San Antonio, and Skidmore is more level country, much of which was formerly occupied by extensive, open grasslands, but which now shows over much of the territory dense thickets of mesquite, cat's-claw, haujilla, huisache, whitebrush, platyopuntias, cylindropuntias, and similar types of vegetation (5 and 8).

It will thus be seen that the most productive portion of the territory lies largely to the east of a line connecting Austin, San Antonio, and Skidmore, which includes the southern extension of the black-land prairie and the timber belt of east Texas and extends through the Fayette Prairie to the edge of the coast prairie on the southeast.

RELATION OF DISEASES TO ENVIRONMENTAL FACTORS.

The direct relationship between the environmental factors, both edaphic and climatological, and the presence or absence of diseased conditions of the vegetation is very evident. No one condition due, perhaps, to the character of the soil is more noticeable than chlorosis. It affects practically the entire vegetation, being more evident in the truck fields, nurseries, and peach orchards. No appreciable effect on cotton and corn was noted. Since this chlorotic condition is limited very largely to the Cretaceous prairies and the lime soils of the Edwards Plateau, it is probably a lime chlorosis (38). It is known, too, that continued droughts cause plants to become chlorotic. This would explain in part the greater prevalence of this condition during the past year.

The downy and powdery mildews, which are quite common in the States farther north, are much less evident. The intense sunlight and the high temperatures are no doubt responsible for this. The spores of certain members of the Peronosporaceæ are known to germinate with difficulty in daylight and to exist only in shaded places where the temperatures are excessive. The amount of sunlight can be indicated and partially appreciated from the fact that the actual number of clear or partly cloudy days ranged during 1909 from

203 to 324 and the cloudy days from 41 to 162 (6) in various parts of the territory.

Injury to truck crops and nursery stock was especially severe where irrigation was practiced. Nematodes, which thrive best with an abundant supply of moisture, caused the formation of galls and the consequent improper functioning of the root system. While injury from this source is very general over the territory, it is more pronounced in irrigated fields. In similar places *Rhizoctonia* was abundantly present on potatoes, tomatoes, okra, and eggplants.

The excessive drought together with the high temperatures produces a languid condition in the aerial parts of the vegetation and thus renders them more susceptible to the attacks of fungi. This would account for the prevalence of leaf-inhabiting fungi, of which the genus *Cercospora* is an abundant representative. While it is not known that any correlation exists between the presence of this genus and high temperatures, yet it seems more than a coincidence, since *Cercospora* diseases are not nearly so abundant in the Northern States even in arid places or during seasons of drought.

PLAN OF THE WORK.

The collections for this survey were begun in the fall of 1908. These were entirely in the immediate vicinity of Austin, as were those of a part of the following season. The greater part of the work, of necessity, was performed in the months of July, August, and September, 1909, with a less amount during the succeeding months of that year. Then again, in the spring of 1910 a very considerable proportion of time was given to the field work.

Attention was given primarily to the diseases of cultivated plants, with an attempt to cover all the varieties of field, truck, nursery, and orchard crops. As much time as was possible was given to the consideration of greenhouse and ornamental plants, with reasonable emphasis upon shade and forest trees. The natural vegetation could not be entirely left out of account, however, because of the fact that the same organism may be the cause of diseased conditions in both wild and cultivated forms.

Notes on the symptomatology from field conditions were carefully made in the field at the time of collection. The value of accurate observations in the field in regard to the symptoms attending the progress of the various diseases can not be overestimated. Actual determinations of the causal organism would have been impossible in many instances without them.

Many of the facts which must be incorporated in our future pathologies can not be obtained from dry herbarium specimens, but must be recorded in the field while the patients are still alive and not after they are dead and have been stored away in herbarium sepulchres (30).

Within a few days after the collections were made a preliminary diagnosis was made in the laboratory and the notes were completed, accompanied by drawings and actual measurements when it was deemed advisable. In working over the material at a later date it was occasionally found necessary to change the previous determination. The time available permitted only a limited amount of culture work.

It is not to be supposed that the list is by any means complete. The territory, comprising over 30,000 square miles, is too large to be covered in the time which has been devoted to the work. In view of the diversity of crops grown in the various sections and the fact that similar crops may reach the same stage of maturity over a very considerable range at the same time, and that it has not been possible to make the work continuous throughout an entire year, the incompleteness will be properly emphasized. Enough, however, has been done to be very suggestive and indicative of the profitableness of further work.

DISEASES OF FRUIT TREES.

APPLE.

Black-rot (*Sphaeropsis malorum* Pk.).—This is the most common and serious disease of the apple (*Malus sylvestris* Miller) in this section. The foliage of the young plants in the nurseries was abundantly spotted and many twigs and limbs of the trees in orchards were seriously affected or entirely dead.

Specimens collected: Austin, 460, 1270, 1911; Kerrville, 1598; Boerne, 1651, 1652; Nursery, 2552; Stockdale, 2626; Gonzales, 2659, 2660.

Crown-gall (*Bacterium tumefaciens* Erw. Sm. and Townsend).—Trees about 8 years old were found seriously affected in one locality. A chlorotic condition preceded the death of the tree in each case.

Specimens observed: Llano, 1772.

Leaf-spot (*Cercospora mali* Ell. and Ev.).—The spots caused by this fungus are circular or subcircular, 2 to 5 mm. in diameter, silver gray on the upper surface with a narrow brown border, while on the under surface they are of a uniform brown. Badly affected leaves turn yellow and fall from the trees, or they may show extended brown areas of dead tissue in which the gray spots are quite conspicuous. The conidial tufts are very abundant and conspicuous on the gray centers of the upper surface, showing as minute black specks; they are inconspicuous on the brown ground of the under surface, but are fairly abundant. It may be noted that the original description characterizes the fungus as "epiphyllous" (18), while a careful examination of our specimens reveals the fact

mentioned above. The range in size of the spores may be extended from 60 to 70 by 2 to 2.5 μ to 30 to 75 by 2 to 3 μ .

Specimen collected: Gonzales, 2860.

Powdery mildew (*Podosphaera leucotricha* (Ell. and Ev.) Salm.).—Apparently this disease is not common in this territory. The perithecia were abundant on the stems and leaves of the shoots growing from the base of trees.

Specimen collected: Austin, 1273.

APRICOT.

Die-back (*Valsa leucostoma* (P.) Fr.).—Pustules are formed on the apricot (*Prunus armeniaca* L.) just beneath the outer bark. At maturity these heaps rupture the bark and are exposed. While it has been reported on several species of the genus *Prunus*, Rolfs (42) mentions its occurrence also on the apricot. Our specimens show only the *Cytospora* stage.

A small orchard of plums, peaches, and apricots at Round Rock was seriously affected with this disease. The trees were about 8 years old. Some had been completely killed, while others were in a badly crippled condition.

Specimen collected: Round Rock, 2424.

Shot-hole (*Cylindrosporium padi* Karst.).—The symptoms are the same as for the cherry "shot-hole," the foliage becoming perforated with circular openings.

Bacteria were present in abundance in the dead tissue of the spots, and were apparently responsible for the shot-hole effect. Only a few spores of the fungus were present.

Specimens collected: Austin, 1441; Nursery, 2551.

DATE PALM.

Smut (*Graphiola phoenicis* (Moug.) Poit.).—The smut of the date palm (*Phoenix dactylifera* L.) is confined to the leaves. It produces small protuberances, the sporocarps, on both surfaces. The entire leaflets or considerable portions from the tips downward may be brown and dead in case of severe infections. The sporocarps are dark gray or black, 0.2 to 0.8 mm. in diameter; when mature they rupture and extrude a mass of pale chocolate-brown spores. (Pl. VIII, fig. 1.)

An examination of the herbaria at Washington and at the New York Botanical Garden shows that it has previously been collected in Florida, Georgia, California, and Texas, and in conservatories in various Northern States. It has presumably been introduced from the Mediterranean countries where it is not uncommon (26).

Specimens collected: Beeville, 1849; Victoria, 2525; Falfurrias, 2453.

FIG.

Die-back (*Diplodia sycina* Mont. var. *syconophila* Sacc.).—Trees of the fig (*Ficus carica* L. var.) on which this disease is present have dead branches sometimes extending well down toward the trunk.

Underneath the bark, and often breaking through, are densely aggregated, black pycnidia, 350 to 400 μ in diameter, containing oval to-elliptical, brown, two-celled spores, 18 to 35 by 9 to 14 μ .

Specimens collected: Beeville, 1843, Luling, 2242.

Leaf-blotch (*Cercospora fici* Heald and Wolf, 32).—This trouble appears late in the summer, forming large angular or irregular spots on the leaves. The spots are dirty brown above with a darker border and uniformly yellowish brown below. They vary in size from 1.5 to 10 mm., and when confluent may exceed this measurement. The conidiophores are borne in dense fascicles on the upper surface, 24 by 4 μ , and are dilute brown. The conidia are clavate, brown, 60 to 180 by 3 to 4.5 μ , and many septate. (Pl. II, fig. 8.)

The disease was very abundant in several localities, involving half the leaf surface and causing the leaves to fall.

Specimens collected: Victoria, 2501; Cuero, 2593 (type specimen); Flatonia, 2711; Hallettsville, 2784.

Root-knot (*Heterodera radicicola* (Greef) Mül.).—Both mature trees in the orchard and cuttings in the nursery are affected. Sometimes the roots near the surface of the ground are abundantly covered with the galls. On the older trees it is productive of no apparent injury.

Specimens collected: Beeville, 1848; Nursery, 2555.

Root-rot (*Ozonium omnivorum* Shear).—This trouble was observed in two nurseries in which it was very common and productive of serious loss among the cuttings.

Specimens collected: New Braunfels, 1678; Beeville, 1851.

Rust (*Physopella fici* (Cast.) Arth.).—The circular yellowish-brown sori about 1 mm. in diameter are produced in great numbers on the lower surface of the leaves. This disease appears in such abundance in late summer as to cause the yellowing of the leaves and much defoliation.

Specimens collected: Austin, 458; Falfurrias, 2458.

Rusty-leaf (*Cercospora bolleana* (Thm.) Speg.).—Small yellowish-brown spots 1 mm. or less in diameter appear on the foliage. The spots are more prominent and more yellow on the under surface than on the upper. When the spots are abundant a considerable amount

of yellowing of the foliage results. This fungus is responsible for much early defoliation of fig trees. (Pl. II, fig. 7.)

Specimens collected: Austin, 1907; Lulling, 2243; Seguin, 2320; Georgetown, 2363; Victoria, 2333; Cuero, 2301; Stockdale, 2343; Gonzales, 2674; Hallettsville, 2787.

ORANGE AND LEMON.

Damping-off (*Phoma* sp.).—This is the most serious trouble of the young plants of *Citrus trifoliata* L. in the nursery. Often a large percentage of the plants will be yellow or completely dry and dead. Near the ground level will be found a sunken area, 12 to 19 mm. long, on which are black dots, the pycnidia. These pycnidia are 150 to 200 μ in diameter and the spores are 5 to 7 by 3 μ . Several plants in the row may be dead and the adjacent plants apparently unaffected. The manner in which the fungus gains entrance is not known. Where the ground has been allowed to remain wet in low places the loss is greatest.

It is not possible definitely to assign this *Phoma* to any of the many species of *Phoma* described as occurring on citrus hosts.

Specimens collected: On *Citrus trifoliata* L.—Beeville, 1847; Floresville, 2855.

Leaf-spot (*Cercospora aurantia* Heald and Wolf, 32).—This fungus forms large spots, 6 to 10 mm. in diameter, and suborbicular except when they are marginal. They are dark brown in color with a lighter brown center, and are surrounded by a region of yellow which fades out into the green of the leaf. The conidiophores are formed on the under surface in small groups, brown, septate, 100 to 180 by 5 to 6 μ , showing plainly the points of attachment of the conidia. The conidia are dilutely colored, clavate, 75 to 135 by 4 to 5 μ , and many septate. (Pl. I, fig. 8.)

Specimen collected: On *Citrus aurantium sinensis* L.—Falfurrias, 2446 (type specimen).

Twig-blight (*Diplodia aurantii* Catt.).—The ends of the branches are killed and the black pycnidia which are formed beneath the bark at length protrude.

Specimens collected: On *Citrus trifoliata* L.—Nursery, 2546; Falfurrias, 2447.

Twig-blight (*Sphaeropsis malorum* Pk.).—This fungus has been found on blighted twigs and less frequently on the leaves of *Citrus trifoliata* L. The trouble was observed at the Austin station in a hedge which stood adjacent to some apple trees which were very seriously infected with black-rot.

Specimen collected: On *Citrus trifoliata* L.—Austin, 1324; Cuero, 2596; Falfurrias, 2447; Gonzales, 2677; Nursery, 2544.

Wither-tip (*Colletotrichum gloeosporioides* Penz.).—Both leaves and twigs are attacked. The leaves form brown areas which become

somewhat grayish when the epidermis has been ruptured by the protruding acervuli.

The twigs may be killed back from the tip or along one side, causing the branches to be angular. Some trees were observed on which the disease had worked well down on the trunk.

Specimens collected: (1) On *Citrus limonum* Risso.—Austin, 1443. (2) On *C. aurantium sinensis* L.—Beeville, 1846 (doubtful).

PEACH.

Crown-gall (*Bacterium tumefaciens* Erw. Sm. and Townsend).—Just to what extent this trouble is present on the peach (*Amygdalus persica* L.) is not known. It was observed in two places only.

Specimens collected: Uvalde, 1939; Round Rock.

Die-back (*Valsa leucostoma* (P.) Fr.).—This is the most widely distributed and most serious trouble of the peach. (See also plum and apricot.) The entire tree may be killed or only the smaller branches. Orchards were observed in which nearly all the trees were dead, giving them a very characteristic silvery appearance. The bark is elevated in wartlike nodules covering dark-brown or black pustules. These at length are exposed on the surface. Our specimens show only the *Cytospora* stage.

Specimens collected: San Antonio, 1368, 3170; Kerrville, 1594, 1596; Boerne, 1644; Beeville, 1825; Elgin, 1873; Bastrop, 2038; Lockhart, 2080; San Marcos, 2122; Seguin, 2288; Round Rock, 2423; Victoria, 2521; Nursery, 2557; Stockdale, 2625; Gonzales, 2670; Flatonia, 2731; Yoakum, 2756.

Freckle (*Cladosporium carpophilum* Thm.).—This disease is general wherever the peach is grown, but was collected only a few times, since the peach crop was almost a complete failure in our territory.

Specimens collected: Austin, 1440; Beeville, 1838; Elgin, 1892; Georgetown, 2362.

Rust (*Tranzschelia punctata* (P.) Arth.).—The rust of the peach shows on the upper surface of the leaves as definite, circular, or sub-circular, yellow spots which average about 1 mm. in diameter. The color of the spot on the under surface is the same, but the center of each is occupied by a minute yellowish-brown sorus.

This rust is abundant on peach foliage in some localities and causes defoliation in the latter part of the growing season.

Specimens collected: Austin, 202, 210, 454, 468; San Marcos, 2100; Nursery, 2560.

Shot-hole and leaf-spot (*Bacterium pruni* Erw. Sm.).—This disease is characterized in its typical condition by small, irregular or angular, purplish-brown spots, 2 to 5 mm. in diameter, which are crowded full of bacteria. In some of our collections the spots are less angular and

lack the purple coloration, and the leaves show more or less chlorosis, but only bacteria were found in the dead spots. The diseased tissue frequently drops out, leaving perforations with dead marginal tissue. Rorer (43) has recently shown that the bacterium on the peach is probably identical with the one on the fruit and leaves of the plum, and we have collected the bacterial spots of both hosts from adjacent trees.

Specimens collected: San Antonio, 1365, 1399; Kerrville, 1592; Beeville, 1863; Elgin, 1888; Uvalde, 1933; San Marcos, 2101; Nursery, 2553; Gonzales, 2671.

Twig-blight.—In one locality peach trees were badly blighted, but no indication of die-back was observed. The dead twigs and branches showed an abundance of erumpent pustules which we have referred to *Fusarium sarcocroum* (Desm.) Sacc. It is not probable that this fungus was responsible for the disease.

Specimen collected: Falfurrias, 2456.

PEAR.

Bitter-rot canker (*Glomerella rufomaculans* (B.) Spaul. and Von Schr.).—The cankers caused by this fungus on the pear (*Pyrus communis* L.) have been found in both young and old orchards, and the disease is responsible for a considerable amount of injury. The specimens collected represent rather young twigs, and the cankers show as circular, elliptical, or irregular areas, 1 to 3 cm. long, or they may girdle the twig. In the young stages of development the bark is yellowish brown and slightly tumid and at length cracks away around the margin of the spot, leaving the dead bark more or less isolated. As the spots become older, more or less irregular ruptures are formed; these ruptures are frequently concentrically disposed, while the whole spot becomes somewhat sunken. Only the conidial stage of the fungus was found.

Specimens collected: Kerrville, 1599; Nursery, 2570; Gonzales, 2666; Flatonla, 2714.

Black-rot (*Sphaeropsis malorum* Pk.).—This disease has been observed to cause the characteristic cankers on the branches and the rotting of the fruit.

Specimens collected: Boerne, 1650; Austin, 2219; Georgetown, 2300(a); Nursery, 2572; Stockdale, 2629; Hallettsville, 2786.

Crown-gall (*Bacterium tumefaciens* Erw. Sm. and Townsend).—Collected in an orchard 6 or 8 years old, where about 75 per cent of the trees were dead.

Specimen collected: Llano, 1771.

Fly-speck (*Leptothyrium carpophilum* Pass.).—Minute black specks appear on the fruit, rendering it unattractive.

Specimens collected: Cuero, 2599; Hallettsville, 2794.

Fire-blight (*Bacillus amylovorus* (Burr.) Trev.).—This trouble is rather common in our territory and is responsible for a very considerable amount of damage to the pear trees, blackening the leaves and twigs.

Specimens collected: Austin, 1319; Brenham, 1460; Boerne, 1657; Elgin, 2001; Lockhart, 2081; San Marcos, 2123; Nursery, 2571; Cuero, 2600; Stockdale, 2628; Flatonia, 2713; Hallettsville, 2785.

Leaf-blight (*Cercospora minima* Tracy and Earle.).—This fungus produces irregular angular areas 1 to 10 mm. or more in diameter, brown or sometimes showing a grayish color in older portions, and frequently bounded by the principal veins. Spots may be few in number, or they may be sufficiently abundant to coalesce and nearly cover the leaf. Affected leaves frequently show a considerable amount of chlorosis, and many fall from the tree. In several localities the pear trees were nearly defoliated by this disease.

Specimens collected: Victoria, 2511; Nursery 2541; Cuero, 2605; Gonzales, 2707; Flatonia, 2712; Hallettsville, 2775; Falfurrias, 2454.

Leaf-spot (*Fabraea maculata* (Lev.) Atk.).—These spots are grayish brown, circular, and about 2 to 4 mm. in diameter. The black pycnidia are sparsely present on the upper surface.

Specimens collected: Austin, 364; New Braunfels, 1705; Llano, 1761; Stockdale, 2630.

Rust-spot (*Gymnosporangium* sp?).—These are the Phyllosticta-like infections of a rust. Small circular spots about 2 or 3 mm. in diameter are formed. They are brown with a very dark border and a central dark cluster of spermagonia.

Specimen collected: New Braunfels, 1689.

PERSIMMON.

Black leaf-spot (*Cercospora fuliginosa* Ell. and Kellerm.).—Affected leaves of the persimmon (*Diospyros* sp.) show circular or subcircular spots, 1 to 5 mm. in diameter, on the upper surface black with yellow border; on the under surface purplish black with indefinite border. With maturity of spots the centers on both surfaces may become brown or gray. In some cases the leaves turn yellow and fall, while in others extended brown, dead areas may be produced before the leaf is cast.

Our specimens differ from the original description only in the size of the spots (1 to 2 mm.).

Specimens collected: On *Diospyros kaki* L.—New Braunfels, 1706; Georgetown, 2361; Victoria, 2537; Stockdale, 2642. All specimens except 2361 are immature infections.

Leaf-spot (*Cercospora kaki* Ell. and Ev.).—The spots caused by this fungus (16) are yellowish brown below, with a very dark, almost black border, angular, 2 to 5 mm. in diameter or occasionally larger, the veins frequently marking the edge of the spot. On the upper surface the spots are darker brown with definite dark border, the center becoming grayish and showing numerous black conidial tufts. The affected leaves become chlorotic and fall.

The conidial tufts are epiphyllous, very abundant, almost black, and are composed of a dense aggregate of dark-brown, septate hyphæ, which extend 30 to 45 μ above the leaf surface and produce an aggregate having the appearance of a pseudoparenchyma for an equal distance below the leaf surface. Spores densely fasciculate, olivaceous, nearly straight, 3 to 5 septate, slightly clavate, cells sometimes two guttulate, 45 to 60 by 3 to 4 μ . (Pl. VII, fig. 3.)

Our specimens differ from the type in the size and character of the conidiophores and the colored, definitely septate spores.

The disease was very abundant in the localities where it was observed.

Specimens collected: On *Diospyros kaki* L.—Gonzales, 2851; Hallettsville, 2778.

Leaf-spot and fruit-rot (*Phyllosticta biformis* Heald and Wolf, 32).—The Mexican persimmon is affected by a fungus which produces black pycnidia in clusters upon the upper surface of the leaves. At first they are surrounded by the green tissue, but later a dark-margined spot 2 to 5 mm. in diameter is formed which is grayish with the black pycnidia distinctly visible. The pycnidia show on the fruit as minute pustules or slightly sunken spots, but are not very evident on account of the dark color of the fruit.

The pycnidia on the leaves are globose, 150 μ in diameter, ostiolate, and produce an abundance of hyaline, densely granular spores, 6 by 9 μ . (Pl. V, fig. 8.) The pycnidia on the fruit are much more flattened, are covered by the very thick epidermal wall, and contain spores similar to those on the leaf except that they are dilute brown in color. (Pl. V, fig. 9.)

Specimens collected: On *Diospyros texana* Scheele—Llano, 1739; Austin, 1548, 2896 (type specimen).

PLUM.

Bacterial leaf-spot (*Bacterium pruni* Erw. Sm.).—This is very probably the same organism which has been described in this report as occurring on the peach. It produces on the plum (*Prunus* spp.) irregular dark areas which sometimes show somewhat of a shot-hole effect. This diseased tissue, however, is crowded with bacteria.

Specimens collected: Uvalde, 1934; San Marcos, 2132.

Bacterial twig-canker.—The first indication of the disease on the twigs is the swollen longitudinal ridges of the cortex. In cross section this ridge shows numerous radial rifts extending outward to just below the epidermis. Eventually these radial rifts extend outward through the epidermis, and open longitudinal slits are produced. Bacteria are abundantly present in the cankered tissue. This may be the same organism which attacks the leaves and fruits. It has been previously reported (29) on the twigs. This is a very general trouble of the plums of this section. (Pl. VIII, fig. 3.)

Specimens collected: San Antonio, 1400; Austin, 1433; Seguin, 2290.

Die-back (*Valsa leucostoma* (P.) Fr.).—The symptomatology is identical with a trouble described under the same name as occurring on the peach. This, too, is present to a very considerable extent.

Specimens collected: Austin, 1439; Kerrville, 1597; Beeville, 1862; Seguin, 2285; Round Rock, 2422; Victoria, 2522; Stockdale, 2627; Gonzales, 2669.

Leaf-spot (*Phyllosticta congesta* Heald and Wolf, 32).—On the upper surface of the leaf are very numerous brown areolæ bounded by the veins of the leaf. The lower surface may not be discolored. These minute spots, 0.5 to 0.8 mm. in diameter, fuse. Each contains at its center a single black pycnidium 50 to 125 μ in diameter. The pycnidia contain globular or slightly oval clear spores 6 to 9 μ in diameter.

Specimen collected: Boerne, 1554 (type specimen).

Rust (*Tranzschelia punctata* (P.) Arth.).—The sori are frequently so abundant as to make the leaf seem uniformly chocolate brown. In one orchard the trees were very seriously affected.

Specimens collected: Austin, 450, 467; Cuero, 2595.

Shot-hole (*Cylindrosporium padi* Karst.).—This is the most general trouble of the plum, producing brown, circular areas which drop out, giving the "shot-hole" effect.

Specimens collected: Austin, 449, 1279, 1431; San Antonio, 1387; Brenham, 1461; Kerrville, 1593; Boerne, 1655; New Braunfels, 1704; Llano, 1758; Beeville, 1839, 1850; Elgin, 1882; Bastrop, 2039; Luling, 2244; Seguin, 2291; Georgetown, 2364; Round Rock, 2404; Victoria, 2508; Nursery, 2550; Cuero, 2598; Stockdale, 2620; Gonzales, 2672; Flatonia, 2734; Hallettsville, 2781.

Silver-twig.—The bark on the twigs becomes silvery in appearance. It is found to be infested with the brown septate filaments of a fungus, which grow just beneath the epidermis. The surface cells are raised so as to admit air, thus producing the silvery coloration.

Specimen collected: Falfurrias, 2457.

DISEASES OF SMALL FRUITS.

BLACKBERRY.

Leaf-spot (*Septoria rubi* Westd.).—This disease was observed in only two localities, as the blackberry (*Rubus* sp.) is not commonly cultivated in this section. The foliage was very copiously spotted.

Specimens collected: Llano, 1765; Floresville, 2357.

DEWBERRY.

Leaf-spot (*Septoria rubi* Westd.).—This fungus produces on the dewberry (*Rubus* sp.) purple-margined, grayish-centered spots, 1 to 2 mm. in diameter. It is abundantly present everywhere on both wild and cultivated forms.

Specimens collected: Austin, 375, 1268, 1318; San Antonio, 1364, 3150; Brenham, 1464; Boerne, 1658; New Braunfels, 1693; Luling, 2271; Seguin, 2323; Georgetown, 2360; Victoria, 2514; Gonzales, 2675; Flatonia, 2728.

Leaf-spot (*Cercospora rubi* Sacc.).—Large, brown, irregularly outlined areas characterize this disease. It is perhaps as generally present as the other leaf-spot and as destructive.

Specimens collected: Elgin, 1871; Bastrop, 2058; San Marcos, 2116; Luling, 2246; Round Rock, 2411; Victoria, 2504; Nursery, 2554; Cuero, 2594; Flatonia, 2728; Yoakum, 2763; Hallettsville, 2782.

GRAPE.

Black-rot (*Guignardia bidwellii* (Ell.) Viala and Ravaz).—This is the most common and most destructive disease of the grape (*Vitis* spp.). On the leaves it produces conspicuous, circular, brick-red spots, 2 to 8 mm. in diameter. Embedded in these areas are the black pycnidia. It also occurs very abundantly on the fruit, and in several cases observed the crop was a total failure, leaving dry, wrinkled mummies in place of the normal fruits. It was observed on several varieties of cultivated grapes, among them Thompson's Seedless and the Mission, also on several wild species, as *Vitis cinerea* Engelm., *V. candicans* Engelm., and *V. monticola* Buckl.

Specimens collected: Austin, 1276, 1326, 1412, 1560, 3056, 3062; San Antonio, 1336, 1391; Brenham, 1463; Hempstead, 1499; Kerrville, 1622; Boerne, 1645; Beeville, 1815, 1834, 1835; Bastrop, 2047; Luling, 2231, 2255; Georgetown, 2382; Round Rock, 2405; Gonzales, 2665; Flatonia, 2717; New Braunfels, 1696; Elgin, 1880; Lockhart, 2084; Yoakum, 2758; Hallettsville, 2776.

Downy mildew (*Plasmopara viticola* (B. and C.) Berl. and De T.).—A white, downy coating is produced in spots on the under surface of the affected leaves. It is not at all common in this section, having been observed but once.

Specimen collected: Austin.

Leaf-spot (*Cercospora viticola* (Ces.) Sacc.).—This fungus causes the formation of large, dark-brown, almost black, spots on the upper surface of the leaf which show below as much fainter brown areas. They are somewhat circular in outline and 2 to 10 mm. in diameter. (Pl. VIII, fig. 2.) The conidia formed on the lower leaf surface are clavate, more or less curved, brown, and 42 to 60 by 5 to 7 μ . (Pl. III, fig. 8.)

It becomes very abundant in the late summer, causing the leaves to be badly spotted and producing considerable defoliation. The disease is present on both wild and cultivated forms.

Specimens collected: Austin, 251; Tyler, 1551; Boerne, 1645; New Braunfels, 1695; Llano, 1762; Beeville, 1864; Bastrop, 2027; San Marcos, 2108; Luling, 2250; Seguin, 2306; Victoria, 2513; Nursery, 2561; Cuero, 2591; Stockdale, 2633; Gonzales, 2657, 2692; Flatonia, 2732; Hallettsville, 2777, 2791, 2793; Floresville, 2852.

Sooty mold (*Fumago vagans* (?) P.).—The upper leaf surface is coated over with a black, sooty covering. Observed in only a single locality.

Specimen collected: Luling, 2263.

STRAWBERRY.

Leaf-spot (*Mycosphaerella fragariae* (Tul.) Lindau).—When the spots first appear on the leaves of the strawberry (*Fragaria* sp.) they are brownish or reddish, becoming circular, 3 to 6 mm. in diameter, with a dead white or grayish center and a broad, purplish margin.

Specimens collected: Austin, 1314; Beeville, 1845.

DISEASES OF TRUCK CROPS.

ASPARAGUS.

Blight (*Cercospora asparagi* Sacc.).—On the cladophylls and branches of asparagus (*Asparagus officinalis* L.) diffuse grayish-brown spots are produced. Densely clustered over these areas are dark fascicles of conidiophores and conidia. Large branches, especially on the older parts of the plant, are killed.

Specimens collected: Victoria, 2505; Floresville, 2853.

Rust (*Puccinia asparagi* DC.).—The rust of asparagus was observed in only one locality. This can be explained by the fact that asparagus is rarely cultivated in the territory covered by this survey.

Specimens collected: Austin, 383, 1916, 2946.

BEAN.

Anthrachnose (*Colletotrichum lindemuthianum* (Sacc. and Magnus) Briosi and Cav.).—The anthrachnose is generally prevalent on beans

(string or snap bean, *Phaseolus vulgaris* L.) throughout our territory. Only a few specimens were collected, since the bulk of our field work was done after most of the crop had been harvested. Records from pickings in one garden (Golden wax) in Austin were obtained with the following result: Picking May 17, no anthracnose; May 21, 4.35 per cent; May 26, 100 per cent.

The rapid increase between May 21 and 26 was favored by an abundance of rain.

In some localities the Kentucky Wonder, a climbing variety with green pods, is seriously affected. The foliage is little affected by this disease, but bacterial blight is often present and may be erroneously diagnosed as anthracnose.

Specimens collected: Austin; San Antonio, 1395; Llano, 1764.

Stem anthracnose (*Colletotrichum caulicolum* Heald and Wolf, 32).—A destructive disease of the Kentucky Wonder bean, observed in a single locality, was found to be due to this fungus. A superficial examination of the affected field showed a considerable number of plants which were completely dead, others were dying, while still others that were less affected exhibited more or less chlorosis of the foliage. An examination of the root system showed it to be in normal condition, while the only deviation from normal in the foliage was the marked chlorosis.

An examination of the stems showed that brown, depressed cankers were present an inch or more above the ground level. The cankers were longitudinally elongated (20 to 40 mm.), more or less irregular, rough and frequently somewhat fissured or open. On the chlorotic plants the canker occupied one side of the stem, on the plants that were dying the stem was nearly girdled, and on all dead plants examined the canker had completely encircled the stem. (Pl. VI, fig. 8.)

Acervuli do not occur on the young cankers, but nearly mature or complete cankers show a few which are visible to the naked eye as small black specks (Pl. VI, fig. 8 (a)), while they become much more abundant on the stems of plants which have been dead for a few days.

Acervuli scattered, black when mature, low convex, 150 to 250 μ in diameter (Pl. VI, fig. 6); setæ abundant, brown, septate, blunt pointed or sometimes tapering, 60 to 120 by 3.5 to 4 μ ; conidiophores nearly half the length of the setæ, cylindrical, hyaline, generally one or two septate; spores falcate, hyaline, granular, and 18 to 30 by 3.5 to 4 μ . (Pl. VI, fig. 7.)

Two species of *Colletotrichum* have previously been reported as occurring on *Phaseolus* species. *Colletotrichum lindemuthianum* (Sacc. and Magnus) Briosi and Cav. is the cause of the common

anthracnose. It may be noted that this species is still retained under the genus *Gloeosporium* by Lindau (37), since the production of setæ is of such rare occurrence. It is known to attack seeds, pods, leaves, and stems. *Colletotrichum lagenarium* (Pass.) Ell. and Hal., has been reported as occurring on different species of beans by two different writers (28 and 50). The report rests on the assumption by Halsted that the two above-mentioned species are identical.

The identity of these two species is not considered sufficiently established (37), so they must still be treated as separate. A comparison of our species with the two mentioned may be made as follows:

TABLE V.—Comparison of characters of species of *Colletotrichum*.

Characters.	<i>C. caulicolum</i> .	<i>C. lindemuthianum</i> .	<i>C. lagenarium</i> .
Conidio- spores.....	30 to 60 by 3 μ	45 to 50 μ	15 to 20 by 3 to 5 μ .
Spores.....	Falcate, pointed, 18 to 30 by 3.5-4 μ .	Oblong, straight or slightly curved, rounded ends, 15 to 19 by 3.5 to 5.5 μ .	Ovate oblong, often inequilateral, rounded ends, 16 to 18 by 5.5 μ .
Setæ.....	Abundant, terete, generally blunt pointed.	Few or absent, terete, fusoid	Few or absent, terete, fusoid.

A comparison of the above characters will make it plain that our specimens represent a new species, which has been described in *Mycologia* (32).

Specimen collected: Uvalde, 1963 (type specimen).

Bacterial blight (*Bacterium phaseoli* Erw. Sm.).—This disease is common on the foliage of both string and Lima beans, but the symptomatology is somewhat different in each. On the leaves of string beans it causes extended, brown, dead areas which appear near the margin or tip and advance into the leaf, or the original foci may be removed from the margin and so cause a conspicuous spotting which is generally accompanied by more or less chlorosis. On the Lima bean the progress of the disease is often marked in the same way, but frequently small circular or somewhat irregular reddish pustules are present. These pustules are found filled with an abundance of bacteria. This symptom has been observed by the senior writer, in Nebraska, and a somewhat similar condition is reported by Clinton (7). A bacterial rot of the pods, due to the same organism which affects the leaves, and affecting both green-podded and yellow-podded varieties, has been observed. It appears first as small watery or pellucid areas along the sutures, which spread and give an opportunity for the inroads of fungi. This bacteriosis of the pods is especially favored by frequent and abundant rains.

Specimens collected: (1) On *Phaseolus vulgaris* L.—San Antonio, 1406 (leaves and pods); Austin, 1427; Stockdale. 2641. (2) On *P. lunatus* L.—Austin, 1540; San Antonio, 1784; Uvalde, 1932.

Chlorosis.—In one truck garden Kentucky Wonder beans were found suffering from chlorosis to a marked extent. The plants were decidedly chlorotic and had made only a stunted growth. The roots were sound, and neither fungous nor bacterial lesions could be found on the aerial portions. A general examination of the field showed, however, that the hypocotyls extended 4 to 6 inches below the surface of the ground. This abnormal length was due to deep planting with subsequent ridging of the rows to provide irrigation furrows between rows. It seems probable that this abnormal depth of the roots, combined with excessive irrigation was the cause of this trouble.

Specimen observed: Uvalde, 1965.

Leaf-spot (*Cercospora canescens* Ell. and Martin).—A leaf-spot disease of the Lima bean caused by the above fungus was observed in a single locality. The spots are subcircular or angular, 1 to 5 mm., with a gray center surrounded by a narrow, definite, reddish-brown border, slightly less pronounced upon the under surface. The spots are isolated, either few or abundant, and do not cause chlorosis to any extent. (Pl. IX, fig. 3.)

Conidiophores are equally abundant on both surfaces, densely caespitose (Pl. II, fig. 5), brown below, becoming hyaline tipped, several septate, irregular, nodose in distal portion, 60 to 105 by 3 to 4.5 μ ; spores hyaline, slender club shaped, straight or curved, one to many septate, 100 to 210 by 3 to 4.5 μ , or sometimes as short as 30 μ and rarely equaling 6 μ in diameter. (Pl. II, fig. 6.)

Six different species of *Cercospora* have been described as affecting the various species of *Phaseolus*. The sizes of the spores of these species are as follows: *Cercospora phaseolina* Speg., 20 to 45 by 3 to 3.5 μ ; *C. phaseolorum* Cke., 40 to 50 by 4 μ ; *C. columnaris* Ell. and Ev., 40 to 60 by 5 μ ; *C. cruenta* Sacc., 60 to 80 by 4 μ ; *C. canescens* Ell. and Martin, 100 to 120 by 5 to 6 μ ; *C. olivascens* Sacc., 130 to 150 by 4 to 4.5 μ .

It may be noted that our specimens show a size of spore different from that recorded for *C. canescens* Ell. and Martin, but an examination of the specimens in the herbarium of the New York Botanical Garden shows that they should be referred to this species.

Specimen collected: Georgetown, 2365.

Powdery mildew (*Erysiphe polygoni* DC.).—This fungus forms a dense white coating on the leaves causing them to become yellow and dry. A crop grown in September was a total loss, and the June crop was seriously affected in the one locality where it was observed.

Specimen collected: San Antonio, 3149.

Root-rot (*Ozonium omnivorum* Shear).—This trouble caused the death of a large portion of a plat of snap beans in a truck garden in a single locality. Black-eyed peas occupied an adjacent plat, and the disease affected portions of both, beginning at the end and advancing to form a distinct semicircular area, about half of the semicircle being occupied by each species.

Specimen collected: Uvalde, 1944.

Root-rot (*Rhizoctonia* sp.).—A few plants of "frijole" beans in an irrigated field were affected with this disease.

Specimen collected: On Brack ranch, 30 miles west of Cotulla, 2185.

Rust (*Uromyces appendiculatus* (P.) Lk.).—This disease was observed in an irrigated truck garden, and also in the University garden at Austin. The maximum development of the trouble was not reached till after most of the crop had been harvested, so that only a small amount of loss resulted.

Specimens collected: Uvalde, 1947, 1948; Austin, 3129.

BEET.

Leaf-spot (*Cercospora beticola* Sacc.).—The presence of the subcircular, dry, pallid blotches on the leaves of the beet (*Beta vulgaris* L.) was very commonly observed. The disease was not, however, sufficiently abundant to cause a great amount of injury.

Specimens collected: Austin, 369, 1322, 1429, 3042; San Antonio, 1376, 3177; New Braunfels, 1716; Sabinal, 1967; Georgetown, 2366.

Root-knot (*Heterodera radiculicola* (Greef) Mül.).—This trouble was quite common, especially in irrigated gardens or low moist ground, but was not serious.

Specimens collected: Austin, 3137; San Antonio, 3148.

CABBAGE.

Leaf-spot (*Cercospora blorum* B. and Br. (?)).—The fungus which is the cause of this leaf-spot on the cabbage (*Brassica oleracea capitata* L.) produces pale, subcircular areas 1 to 5 mm. in diameter surrounded by a slightly raised, faintly purple border. Conidial tufts amphigenous, more conspicuous in the center of the spots. Conidiophores densely tufted, pale brown, sparingly septate, 60 to 120 by 4 to 4.5 μ . Conidia long-clavate, tapering, straight or much curved, hyaline or faintly smoky, many septate, 3 to 5 by 100 to 270 μ . Our specimens are somewhat doubtfully referred to this species, since the published descriptions include no information concerning size of conidiophores or spores, and the original specimens showed no

spores (10). Present only on languid leaves and not sufficiently abundant to cause any material injury.

Specimen collected: Georgetown, 2367.

CARROT.

Rhizoctonia root-rot (*Corticium vagum* B. and C. var. *solani* Burt.).—The roots of the carrot (*Daucus carota* L.) become covered by white, ropy strands of the fungus. No serious rotting was observed to result.

Specimen collected: San Antonio.

CASABA.

Sooty mold (*Fumago vagans* (?) P.).—The mycelium on casaba (*Cucumis melo* L.) forms a black or brown sooty crust on the leaves, most abundant on the upper surface. Plant lice were abundant on the foliage.

Specimen collected: New Braunfels, 1725.

CUCUMBER.

Root-knot (*Heterodera radiculicola* (Greif) Mül.).—Vines of the cucumber (*Cucumis sativus* L.) which were affected remained stunted and later were killed. In one field about one-third of the plants were dead by the time they should have been bearing.

Specimens collected: Austin, 3138; San Antonio, 3146.

EGGPLANT.

Fruit-rot (*Gloeosporium melongenae* Ell. and Hals.).—The fruits of the eggplant (*Solanum melongena* L.) affected with fruit-rot show brown, sunken areas over which are scattered the black acervuli. With the progress of the disease the fruits are completely rotted.

Specimens collected: Austin, 1906; Uvalde, 1943.

Fruit-rot (*Colletotrichum* sp.).—On the diseased areas are very dense aggregates of black acervuli, varying in diameter from 100 to 250 μ . Brown, taper-pointed, septate setæ, 100 to 150 by 5 μ project profusely from all parts of the acervulus. The conidiophores are slightly club shaped, 12 to 15 by 3 to 4 μ , and the spores are 30 to 36 by 3 to 4 μ , clear, guttulate, falcate, frequently blunt on one end. This has not been definitely associated with any described species and may represent a new species. *Gloeosporium melongenae* was also present on the same fruits, which were completely destroyed by the combined action of the two fungi.

Specimens collected: Austin, 1915, 2430.

Root-rot (*Rhizoctonia* sp.).—The plants which are affected remain dwarfed for a time and then wilt and die. The stems up to the ground level and a little above are sunken and have little wartlike nodules. The loss was quite serious in an irrigated garden where it was observed.

Specimen collected: San Antonio, 1329.

GLOBE ARTICHOKE.

Leaf-spot (*Cercospora obscura* Heald and Wolf, 32).—The presence of this disease on the globe artichoke (*Cynara scolymus* L.) is made manifest by the circular gray spots, varying in diameter from 1 to 2 mm., which appear on the upper surface of the leaf in great numbers. Each spot has a faint brown border, with the tufts of conidiophores on the upper surface. Since the lower surface of the leaf is covered by a silvery tomentum the spots appear as slightly darker areas.

The conidiophores are in groups of from four to seven, epiphyllous, nonseptate, varying in length from 50 to 80 μ , and in width from 4 to 5 μ , brown, with a hyaline tip. The conidia are cylindrical in shape, 40 to 74 by 3 to 4 μ , three to four septate, dilutedly colored, and straight or curved. (Pl. III, fig. 6.)

Specimen collected: Beeville, 1861 (type specimen).

MUSKMELON.

Anthracnose (*Colletotrichum lagenarium* (Pass.) Ell. and Hals).—The appearance of large, dead, brown patches on the leaf of the muskmelon (*Cucumis melo* L.) marks the presence of this fungus.

Specimen collected: Beeville, 1827.

Leaf-blight (*Alternaria brassicae* (B.) Sacc. var. *nigrescens* Pegl.).—Large brown spots are formed on the foliage, attaining 1 cm. in diameter. When numerous the leaves turn brown and curl. It was observed to be sufficiently abundant in one field to cause a very serious loss, and has been reported to be a very destructive blight south of our territory.

Specimens collected: Austin, 1425, 3136; Hallettsville, 2904.

Root-knot (*Heterodera radicola* (Greef) Mül.).—This trouble was observed in an irrigated garden where the plants remained stunted for a time, and at length succumbed. The crop was an entire loss. (Pl. IX, fig. 2.)

Specimens collected: San Antonio, 1327; Austin, 3135.

OKRA.

Root-knot (*Heterodera radiculicola* (Greef) Mül.).—This disease is common on okra (*Abelmoschus esculentus* Moench.), but was observed to be the cause of serious loss only in an irrigated garden.

Specimens collected: San Antonio, 1894; Llano, 1770; Stockdale, 2631; Yoakum, 2768.

Root-rot (*Ozonium omnivorum* Shear).—Observed in a single locality where the plants were stunted and chlorotic.

Specimens collected: New Braunfels, 1711, 1712.

Root-rot (*Rhizoctonia* sp.).—This fungus caused the destruction of the smaller roots and the constriction of the stem at the ground level.

Specimen collected: San Antonio, 1330.

PARSLEY.

Root-knot (*Heterodera radiculicola* (Greef) Mül.).—This trouble was observed on parsley (*Petroselinum sativum* Hoffm.) in a single locality.

Specimen collected: San Antonio, 3144.

Root-rot (*Ozonium omnivorum* Shear).—This diseased condition is characterized by the same symptomatology as when this fungus is present on other herbaceous hosts.

Specimen collected: San Antonio, 3143.

PARSNIP.

Rhizoctonia root-rot (*Corticium vagum* B. and C. var. *solani* Burt).—The white strands of fungous filaments surround the roots of the parsnip (*Pastinaca sativa* L.), but do not cause any material loss.

Specimen collected: San Antonio.

PEA.

Powdery mildew (*Erysiphe polygoni* DC.).—This fungus forms a white coating on the leaves and pods of the pea (*Pisum sativum* L.), causing them to become brown and dry. It is probably quite common throughout the territory.

Specimen collected: Austin, 3130.

PEPPER.

Anthrachnose (*Colletotrichum nigrum* Ell. and Hals.).—The fruit of the pepper (*Capsicum annuum* L.) sometimes shows large, brown, sunken areas. The black acervuli are either scattered over the diseased spot or zonately arranged.

Specimen collected: Uvalde, 1951.

Bacterial leaf-spot.—The leaves have small, elevated, brown spots from 0.5 to 1 mm. in diameter. The leaf tissue between them is more or less chlorotic. Each pustule is crowded full of bacteria. No record has been found of a pepper disease due to these organisms.

Specimen collected: Uvalde, 1950.

Fruit-spot.—The sweet pepper is very commonly spoiled by the formation of large, dry, brown, more or less sunken areas on the side exposed to the sun. An *Alternaria* was found to be present, but inoculations into healthy fruits failed to reproduce the spots. This would suggest that the trouble is physiological and that the fungus associated with it is merely a saprophyte.

Specimens collected: Austin, 1536; San Antonio, 1733; New Braunfels, 1683.

Leaf-spot (*Cercospora capsici* Heald and Wolf, 32).—Leaves infested with this fungus form spots 1 to 7 mm. in diameter, mostly circular or subcircular. The spots are raised on the upper surface, brown at first, later becoming grayish brown. They are margined by a very definite darker zone, outside of which is a more or less extended halo of yellow. Where the spots are abundant, the leaves become chlorotic, then wilt and fall. The conidiophores are borne on both surfaces, brown, grouped in clusters of 10 to 15, 30 to 60 by 4.5 to 5.5 μ , and are occasionally septate. The conidia are borne on the tips, are dilutely brown, 75 to 125 by 4 to 5 μ , clavate, generally straight, and several septate. (Pl. IV, fig. 7.)

Specimen collected: Cuero, 2592 (type specimen).

POTATO.

Early blight (*Alternaria solani* (Ell. and Martin) J. and G.).—This was observed to be abundant on the potato (*Solanum tuberosum* L.) in several localities, producing large, irregular, brown spots.

Specimens collected: San Antonio, 1402, 3145; Kerrville, 1601; Austin, 3134.

Rhizoctonia disease (*Corticium vagum* B. and C. var. *solani* Burt).—The stems are cankered and have the characteristic pustules. The tubers also are very frequently destroyed, especially in irrigated gardens, during a rainy period. (Pl. X, fig. 2.)

Specimen collected: San Antonio, 3147.

Scab (*Oospora scabies* Thax.).—Observed in a single locality.

Specimen collected: San Antonio, 1402a.

RADISH.

Powdery mildew (*Erysiphe polygoni* DC.).—The leaves of the radish (*Raphanus sativus* L.) at first are covered with a powdery coating, becoming chlorotic and at length entirely dry.

Specimen collected: Cotulla, 2931.

SPINACH.

Leaf-spot (*Cercospora beticola* Sacc.).—This fungus on spinach (*Spinacia oleracea* L.) forms numerous subcircular areas, 1 to 3 mm. in diameter, with a slightly raised margin. The dark, amphigenous conidiophores cause the larger part of the diseased area to be brown. No record has been found of the occurrence of a *Cercospora* on this host, but as the symptomatology and size of conidiophores and spores are similar to *C. beticola*, and as the hosts are closely related, it is in all probability the same species.

Specimen collected: Austin, 3039.

SQUASH.

Anthrachnose (*Colletotrichum* (?) *nigrum* Ell. and Hals.).—This fungus was found on squash (*Cucurbita* spp.) in the same field with the *Colletotrichum*, which was attacking sweet peppers, and agrees with it morphologically. From this it may be inferred that it is probably the same. On the fruits are formed numerous dark acervuli, often concentrically arranged.

Specimen collected: On cymling (*Cucurbita pepo* L.)—Uvalde, 1941.

Fruit-rot (*Botrytis cinerea* P.).—In one field the young fruits were seriously affected with this fungus. It apparently starts on the decaying flower and in a few days the entire fruit is destroyed and covered by a black, fungous growth. (Pl. X, fig. 3.)

Specimen collected: On cymling (*Cucurbita pepo* L.)—Austin.

Leaf-spot (*Macrosporium* sp.).—Rounded dry areas surrounded by an area of yellow are formed on the leaves. The center may become grayish with age. We were not able definitely to associate the fungus with any given species.

Specimen collected: On cushaw (*Cucurbita moschata* Duch.)—Beville, 1840.

Leaf-spot (*Cercospora cucurbitae* Ell. and Ev.).—Rounded brown spots 1 to 4 mm. in diameter, becoming whitish with an elevated border, appear on the foliage. The characters of the conidiophores and conidia agree with the original description (17), except in size, the conidiophores being sometimes 150 μ long and the conidia reaching 300 μ and being plainly multiseptate.

Specimen collected: On cushaw (*Cucurbita moschata* Duch.)—Hempstead, 1498.

Rhizoctonia root-rot (*Corticium vagum* B. and C. var. *solani* Burt).—A very considerable loss in an irrigated field was due to this fungus, the entire root system being destroyed.

Specimen collected: On cymling (*Cucurbita pepo* L.)—San Antonio, 3151.

Root-knot (*Heterodera radiculicola* (Greef) Mül.).—This was observed in only two localities, but it is probably quite widely distributed.

Specimens collected: On cymling (*Cucurbita pepo* L.)—New Braunfels, 1685; San Antonio, 3152.

SWEET POTATO.

White-rust (*Albugo ipomoeae-panduranae* (S.) Swingle).—This fungus on the sweet potato (*Ipomoea batatas* (L.) Poir.) produces clusters of white pustules on the under surface of the leaves. In young infections the leaves show yellow spots on the upper surface, and as the disease progresses the tissue becomes brown and dead. In severe infections the leaves may show considerable chlorosis in the young stages and in later stages extended brown areas which have been killed.

Specimens collected: San Antonio, 1781; Llano, 1752; Beeville, 1821; Elgin, 2015; Uvalde, 1953; Nursery, 2562; Yoakum, 2765.

Root-rot.—According to the reports of gardeners, root-rot is very prevalent and destructive in certain localities. All field work was done previous to the harvesting of the crop, and no specimens were obtained, hence it is impossible to say which of the various rot-producing fungi are prevalent.

TOMATO.

Leaf-spot (*Septoria lycopersici* Speg.).—This trouble on the tomato (*Lycopersicon esculentum* Mill.) was observed to be especially serious in seed beds. The young leaves become thickly covered with small angular spots having a grayish center and a darker colored border. The disease was not so serious on mature plants.

Specimens collected: Austin, 370, 1307; Llano, 1766; Uvalde, 1952, 1956; Nursery, 2556.

Rhizoctonia disease (*Corticium* sp.?).—The symptomatology is very much the same as in diseases of other hosts caused by the same organism.

Specimens collected: San Antonio, 1380, 3142; Austin, 3139.

Root-knot (*Heterodera radiculicola* (Greef) Mül.).—Probably this is a very general trouble. In several large fields about one-third of the plants had been killed and the others were so stunted that the crop was a complete failure. This is the most serious trouble on tomatoes in the irrigated truck gardens. (Pl. IX, fig. 1.)

Specimens collected: San Antonio, 1328, 3141; Llano, 1769; Beeville, 1842; Elgin, 2011; Uvalde, 1949; Austin, 3132.

TURNIP.

Downy mildew (*Peronospora parasitica* (P.) De By.).—The oldest leaves of the affected turnip plants (*Brassica rapa* L.) were dry and

dead, while those higher up on the plant were chlorotic either entirely or in part. Such leaves are copiously downy white on the lower surface. This disease was very abundant in a truck garden, the only place where it was observed.

Specimen collected: Austin, 3040.

Powdery mildew (*Erysiphe polygoni* DC.).—This fungus causes the characteristic white appearance of the leaves, which at length become yellow and dry.

Specimen collected: Cotulla, 2930.

WATERMELON.

Blossom-end blight and rot.—A very common and destructive disease of the watermelon (*Citrullus vulgaris* Schrad.) is characterized by the blighting and atrophy of the blossom end of the fruit followed by the rotting of the entire fruit. The blossom end turns brown, dries more or less, and remains smaller than the remainder of the fruit. (Pl. X, fig. 1.) The trouble may begin very soon after the blossom stage and the affected fruit may never reach any considerable size, or the trouble may begin later and the fruit may reach nearly normal size before it is destroyed. In some cases observed it was impossible to find any fungus present in the blighted portion, but in the majority of cases the fruit was invaded by a *Fusarium* which transformed the melon into a soft, rotting mass.

The *Fusarium* present comes to the surface on the side of the melon in contact with the soil, and in specimens kept in a damp atmosphere conspicuous pinkish spore tufts are produced over the surface. Only macroconidia, 18 to 24 by 3 μ , falcate, and two septate, have been observed.

The definite etiology of this disease is not known, and it can only be suggested that the blighting is due first to the excessive transpiration at times when root activity is not sufficient to meet the loss, and that the fungus gains an entrance into the dead tissue and then spreads throughout the remainder of the fruit.

This is the most serious trouble of the watermelon and is generally prevalent. The loss may be from 25 to 75 per cent in many cases. The very general prevalence of this disease is such that a more detailed investigation should be undertaken.

Specimens collected: New Braunfels, 1690; Austin, 1870; Beeville, 1817 (collections do not represent the prevalence).

Leaf-spot (*Cercospora citrullina* Cke.).—The oldest leaves of the plant are the first to show these circular spots, 2 to 4 mm. in diameter.

Each is bordered by a dark-brown or purplish zone beyond which is an area of faint yellow. The mature spots have grayish centers.

Specimens collected: Hempstead, 1487; Beeville, 1816; Luling, 2245; Victoria, 2338; Alice, 2494; Nursery, 2545; Stockdale, 2634; Flatonia, 2733; Yoakum, 2764; Hallettsville, 2903.

Sooty mold (*Capnodium* (?)).—The stems, petioles, and leaves become covered over with a sooty, black coating, more abundant on the older parts of the plant. On the late crop in some localities it results in the death of the entire plant. Probably the injury is mostly due to plant lice and the fungus is merely secondary. Dark-brown pycnidia 90 to 120 μ are formed on the surface. The spores are clear, elongated, 5 to 6 by 3 μ , and stream out in tortuous, rope-like strands.

Specimens collected: Elgin, 2000; Bastrop, 2048; Cotulla, 2202.

DISEASES OF CEREALS.

BARLEY.

Covered smut (*Ustilago hordei* (P.) Kellerm. and Swingle).—This smut was present in considerable quantities in barley (*Hordeum* sp.) grown near San Antonio in 1909.¹

Loose smut (*Ustilago nuda* (Jens.) Kellerm. and Swingle).—Barley is not grown as a field crop in the territory covered by this survey, and this material was collected from a plat on the University campus. The brown spore masses occur on the spikelets, which fall away, leaving only the naked rachilla.

Specimens collected: Austin, 3099, 3118.

Rust (*Puccinia graminis* P. var. *hordei* Freeman and Johnson).—This rust was prevalent on barley near San Antonio in 1909.¹

CORN.

Rust (*Puccinia sorghi* S.).—This disease on corn (*Zea mays* L.) is quite general in its distribution but was not observed to be sufficiently abundant to cause any serious loss except in one field of late corn at Flatonia.

Specimens collected: Austin, 1557; Kerrville, 1584; Boerne, 1649; New Braunfels, 1679; San Antonio, 1782; Elgin, 1893; San Marcos, 2102; Gonzales, 2676; Flatonia, 2719; Yoakum, 2751.

Smut (*Ustilago zae* (Beckm.) Ung.).—No loss of any consequence can be attributed to smut, as it was rarely found in abundance. At Uvalde a field of corn was observed which had 40 to 50 per cent of the ears destroyed, but in all other localities smut was rare.

Specimens collected: Austin, 1450; Kerrville, 1583; New Braunfels, 1709; Uvalde, 1962; Hondo, 1997; Cotulla, 2216; Seguin, 2299; Flatonia, 2720.

¹ Notes from E. C. Johnson, Bureau of Plant Industry, U. S. Dept. of Agriculture.

OATS.

Crown-rust (*Puccinia coronata* Cda.).—Rust on oats (*Avena sativa* L.) was not uncommon, but most of our field work was completed after harvest time. Collected from a single locality.

Specimen collected: San Antonio, 1389.

Stem-rust (*Puccinia graminis* P. var. *avenae* Eriks. and Henn.).—Also collected in a single locality.

Specimen collected: San Antonio, 1359.

Smut (*Ustilago avenae* (P.) Jens.).—The loose smut of oats is not uncommon in this territory. Extensive loss has been reported from some sections. Fields were observed with 10 to 15 per cent of the heads destroyed. Inquiry revealed the fact that seed treatment is not practiced to any great extent.

Specimens collected: Austin, 1001, 3117; San Antonio, 1358; San Marcos, 974.

RYE.

Leaf-rust (*Puccinia rubigo-vera* (DC.) Wint. var. *secalis* Carl.).—Rye (*Secale cereale* L.) is not generally grown in this region. Leaf-rust was abundant on plats at the San Antonio Experiment Farm in 1908 and 1909.¹

WHEAT.

Floret sterility (*Stemphylium tritici* Patterson).—This disease was found abundantly in 1909 on the leaves and sterile spikelets of wheat (*Triticum aestivum* L.) near San Antonio. It is closely associated with rusts in causing floret sterility of wheats.¹

Leaf-rust (*Puccinia rubigo-vera* (DC.) Wint. var. *tritici* Carl.).—This rust is abundant on wheat almost every year in the locality of San Antonio and was especially prevalent in 1908 and 1909.¹

Leaf-spot (*Cladosporium graminum* Cda.).—This causes brown to black spots on the leaves of wheat and is often found in sterile florets. It was abundant in the San Antonio region in 1908 and 1909.¹

Loose smut (*Ustilago tritici* (P.) Jens.).—The dusty olive-brown spore masses appear on the heads or spikelets, destroying them entirely and leaving only the naked rachis.

Specimen collected: Austin, 3115.

Stem-rust (*Puccinia graminis* P. var. *tritici* Eriks. and Henn.).—Wheat is not extensively grown in this section, but the rust was found abundantly present on it wherever it was grown.

Specimens collected: San Antonio, 1366; Kerrville, 1602.

Stinking smut (*Tilletia tritici* (Bjerk.) Wint.).—Found sparingly near San Antonio in 1909.¹

¹ Notes from E. C. Johnson, Bureau of Plant Industry, U. S. Dept. of Agriculture.

DISEASES OF FORAGE CROPS.

ALFALFA.

Leaf-spot (*Cercospora medicaginis* Ell. and Ev.).—This disease on the leaves of alfalfa (*Medicago sativa* L.) shows as dark-brown, circular or subcircular areas, 1 to 5 mm. in diameter. The spots on a single leaflet may vary in number from one to nine and with a predominant size of 2 to 3 mm. When the spots are few in number each is surrounded by an indefinite zone of yellow, and when abundant the entire intervening areas become yellow. Many of the affected leaflets fall from the plant, thus producing considerable defoliation.

This disease was first reported from College Station, Tex., in 1891 (20), and has been reported more recently from New York (49).

Specimens collected: San Marcos, 2103; Victoria, 2528; Gonzales, 2700.

Leaf-spot (*Pseudopeziza medicaginis* (Lib.) Sacc.).—Observed only in a single locality, at which place it was very abundant in an irrigated field.

Specimen collected: San Marcos, 970.

Root-rot (*Ozonium omnivorum* Shear).—This disease is caused by the same fungus which produces the well-known root-rot of cotton. It was observed only in a single field, where it caused a loss of 25 to 30 per cent.

Specimen collected: Beeville, 1841.

Rust (*Uromyces medicaginis-falcatæ* (DC.) Wint.).—This disease causes the formation of minute circular or elongated pustules of a reddish-brown color. The epidermis is ruptured and the spore mass is surrounded by the irregular lacerated remains. Only uredo pustules have been observed in our specimens and these are more abundant on the under surface than upon the upper surface of the leaflets (27). Freeman does not mention the occurrence of the pustules upon the upper surface of the leaflets. A single leaflet may show 20 to 60 pustules and still retain its green color in portions not occupied by the pustules, while others having a lesser number of pustules may show considerable yellowing. The disease does not cause serious damage since only a slight degree of defoliation results. It is apparently the least injurious of the three leaf diseases in this territory.

Specimens collected: Collins's Garden, San Antonio, 1390; Brack ranch, Cotulla, 2204.

COWPEA.

Leaf-spot (*Cercospora vignae* Racib.).—This is probably the most common disease of the cowpea (*Vigna unguiculata* (L.) Walp.) in this territory. It produces on the foliage large, circular, brown spots

1 to 2 cm. in diameter. The spots are most commonly isolated, but they may become confluent and irregular. With the abundant production of conidiophores and conidia the areas become dirty gray in color. It causes a serious defoliation of the plants. It was originally described from Java (41), and no mention has been found of its occurrence in this country. (Pl. I, fig. 1.)

Specimens collected: Austin, 1543, 2428; Beeville, 1826; Elgin, 1889, 2006; Uvalde, 1946; Victoria, 2529; Nursery, 2549; Cuero, 2604; Gonzales, 2673; Flatonia, 2730; Yoakum, 2767; Floresville, 2854; Hallettsville, 2902.

Leaf-spot (*Cercospora cruenta* Sacc.).—The large, indefinite, vague spots which this fungus produces characterize the disease. The tissue on the upper leaf surface is paler green or somewhat chlorotic, and the profuse production of conidiophores and conidia on the lower surface renders it dirty gray in color. The spots are largely confluent, often involving the entire leaf and causing its destruction. (Pl. I, fig. 2.)

Specimens collected: Beeville, 1860; Luling, 2259, 2260; Flatonia, 2729; Yoakum, 2752; Austin, 3131.

Root-rot (*Ozonium omnivorum* Shear).—The symptomatology of this disease is the same as that of the cotton root-rot.

Specimens collected: Beeville, 1837; Uvalde, 1945.

Rust (*Uromyces appendiculatus* (P.) Lk.).—This trouble was observed in only one locality where it was not the cause of any serious loss.

Specimen collected: Luling, 2260.

PEANUT.

Leaf-spot (*Cercospora personata* (B. and C.) Ell.).—This disease on the peanut (*Arachis hypogaea* L.) is so common on the mature plants that farmers consider it time to harvest when the leaves are badly spotted. The spots are chestnut brown, beginning as minute specks and increasing to about 4 mm., often, however, to as large as 10 mm. The margin of the spot is yellowish, paling out into the green of the leaf. The conidiophores are present on both surfaces, being more abundant below. The conidia are frequently 100 μ in length. In the original description (14) the fungus is said to be hypophyllous and the conidia may reach a maximum of 50 μ . (Pl. III, fig. 9.)

Specimens collected: Brenham, 1465; Elgin, 2019; Luling, 2235; Nursery, 2566; Stockdale, 2624; Hallettsville, 2905.

DISEASES OF WILD AND CULTIVATED GRASSES.

BERMUDA GRASS.

Leaf-spot (*Helminthosporium giganteum* Heald and Wolf, 32).—This disease on Bermuda grass (*Capriola dactylon* (L.) Kuntze) is characterized by the presence of numerous yellowish or pale straw-colored spots, 0.5 to 1 mm. wide by 1 to 4 mm. long, longitudinally elongated, and with a narrow brown border. The spots are generally absent from the leaf sheath, and when numerous they may become confluent on the laminæ and thus cause somewhat extended dead areas.

The conidiophores are dark brown, many septate, 9 to 12 by 200 to 400 μ , with a slightly bulbous base (Pl. VII, fig. 6); the spores are elongated, cylindrical, with slightly tapering ends, five septate, pale brown, densely granular contents, 15 to 21 by 300 to 315 μ . (Pl. VII, fig. 7.)

Specimen collected: Falfurrias, 2440 (type specimen).

CRAB-GRASS.

Gray-spot (*Piricularia grisea* (Cke.) Sacc.).—Circular or slightly elongated spots appear on crab-grass (*Syntherisma sanguinalis* (L.) Dulac). These spots are dirty yellow or grayish in color, 1 to 5 mm. in diameter, with prominent purple borders. Very frequently the areas are confluent so that the entire leaf tip becomes dry.

Specimen collected: Uvalde, 1936.

Rust (*Uromyces* sp.).—Observed in but a single locality. Affected leaves showed an abundance of sori.

Specimen collected: Falfurrias, 2490.

FEATHER GRASS.

Balansia blight (*Balansia hypoxylon* (Pk.) Atk.).—This fungus on feather grass (*Stipa leucotricha* Trin.) destroys the entire spike, forming around the vascular tissue of the spikelets a pseudosclerotium which is grayish or bluish black on the outside, whitish within, and 4 to 15 mm. in length. (Pl. XI, fig. 1.) The black pulvinate stromata project prominently from this sclerotium. These stromata contain the flask-shaped perithecia. This blight is quite common during the last part of April and the first part of May. When this species was made the basis of a study by Atkinson (2) the host plant of the Texas material was undetermined.

Specimen collected: Austin, 3071.

Smut (*Ustilago hypodytes* (Schl.) Fr.).—The internodes of the inflorescence beginning at their bases are enveloped for the greater part of their length by a dusty, dark-brown spore mass, and the spikelets are destroyed.

Specimens collected: Austin, 2950, 3098.

GRAMA GRASS.

Rust (*Puccinia jamesiana* (Pk.) Arth.).—This rust on grama grass (*Bouteloua* sp.) was observed in a single locality, where it was not abundant.

Specimen collected: Falfurrias, 2481.

JOHNSON GRASS.

Leaf-blight (*Helminthosporium turcicum* Pass.).—The diseased areas on Johnson grass (*Andropogon halepensis* (L.) Brot.) are dark purple, often almost black, from 5 to 10 mm. in diameter, and are elongated parallel to the veins. They are frequently flattened on the side of the veins and show a pronounced zonation. These spots become confluent, resulting in the death of the leaf tips.

Specimens collected: Bastrop, 2024; Luling, 2232; Elgin, 2010; San Antonio, 1409; Sabinal, 1983; Austin, 3036. (The last three are mixed infections, *Colletotrichum* being present.)

Leaf-blight (*Septoria pertusa* Heald and Wolf, 32).—The diseased areas are elongated parallel to the veins and are 1 to 2 cm. in length without a definite margin. The brownish center is surrounded by a yellow zone which pales out into the green. These areas become confluent so that whole leaves are dry and yellowish brown in color. The flask-shaped pycnidia are very abundant on both surfaces and protrude by a short papilla. (Pl. VI, fig. 16.) The conidia are clear, straight, or slightly curved, slightly clavate, 60 to 75 by 3 μ , guttulate, and are extruded so abundantly as to make a white coating. (Pl. VI, fig. 17.)

Specimens collected; Luling, 2270; Flatonia, 2722 (type specimen).

Leaf-spot (*Cercospora sorghi* Ell. and Ev.).—No definitely limited spots are produced by this fungus. The affected areas are reddish purple with a tinge of red along the border. The production of conidiophores and conidia renders the center of these areas somewhat brown.

Specimens collected: Flatonia, 2741; Hallettsville, 2800; Gonzales, 2868. (Immature specimens, *Colletotrichum* being also present.)

Leaf-spot (*Colletotrichum lineola* Cda. var. *halepense* nov. var.).—This fungus on the leaf blades produces circular or slightly elongated spots which have an average length of about 2 mm., but may reach 5 mm. or more in length. The spots have a bright-red border with a

gray or dirty-yellow center, bearing a central cluster of black acervuli. The acervuli are on both surfaces and few in each spot. The spores are falcate, acute pointed, hyaline, 20 to 27 by 4 to 5 μ , and frequently show one to three large granules. The conidiophores are short, 15 μ long, and nonseptate. The setæ are pointed, with slightly bulbous base, 1 to 2 septate, and reach 75 μ in length. (Pl. VI, fig. 15.) Our specimens agree with *C. lineola* Cda. in size of spores and setæ and with *C. andropogonis* Zimm.¹ in symptomatology.

One field was observed where the disease was sufficiently developed to cause the death of the grass.

Specimens collected: Round Rock, 2410 (type specimen), 2427; Falfurrias, 2441, 2727; Yoakum, 2753; Floresville, 2844; Austin, 3036.

Rust (*Puccinia purpurea* Cke.).—This rust occurs so abundantly on the leaves that they are purple, the color being caused by the closely clustered, elongated sori which rupture the epidermis on both leaf surfaces.

Specimen collected: Austin, 121.

JUNGLE RICE.

Gray-spot (*Piricularia grisea* (Cke.) Sacc.).—Circular or oval yellowish areas with purple margins appear on the blades of jungle rice (*Echinochloa colona* (L.) Link). These spots are from 1 to 5 mm. in diameter and become grayish below. The intervening tissues are killed and the leaf tips become dry. (See under "Crab-grass.")

Specimen collected: Uvalde, 1938.

PANICUM.

Black-blotch (*Phyllachora graminis* (P.) Fekl.).—The leaves of Panicum (*Panicum* spp.) become infested with black, shining, stromatic blotches. These are small, mostly less than 1 mm. in diameter, and often confluent. The affected leaves become brown between these spots.

Specimens collected: Austin, 859; Elgin, 1895.

Gray-spot (*Piricularia grisea* (Cke.) Sacc.).—Small elongated or lenticular spots are formed. They are grayish brown with a brown border, and are most abundant toward the tip of the leaf. Chlorosis accompanies this spotting, and large parts of the leaves turn brown.

Specimen collected: On *Panicum texanum* Buck.—Kennedy, 2834.

¹ Dr. Zimmerman, to whom duplicates of our specimens were sent, reports that they are identical with *C. andropogonis* Zimm. Edgerton, who is making a careful study of the Colletotrichums, is of the opinion that *C. lineola* Cda., *C. andropogonis* Zimm., *C. cereale* Manns, and *C. falcatum* Went. may be identical.

REED-GRASS.

Leaf-spot (*Hendersonia arundinacea* (Desm.) Sacc.).—This fungus produces brown, elongated spots on the leaves of reed-grass (*Phragmites vulgaris* (Lam.) B. S. P.). The spots are 1 to 2 cm. in length, most commonly confluent, causing the drying of the leaves. The upper surfaces of the affected areas at maturity become grayish with a brown margin.

Specimen collected: San Marcos, 2109.

SAND BUR.

Smut (*Sorosporium syntherismae* (Pk.) Farl.).—This smut destroys the complete inflorescence of the sand bur (*Cenchrus* sp.).

Specimen collected: Skidmore, 2807.

SILVER BEARD-GRASS.

Black-blotch (*Phyllachora graminis* (P.) Fckl.).—This parasite on silver beard-grass (*Andropogon argyraeus* Schult.) produces on the leaves black, shining blotches. The spots are small, oblong, prominent, sometimes confluent, with a rugulose surface. The fructification is not mature until the leaves are dead and decaying.

Specimens collected: Austin, 297, 356.

Smut (*Tolyposporella bruncki* (Ell. and Gall.) Clint.).—The leaf sheaths inclose a black, powdery mass of spores, which has taken the place of the inflorescence.

Specimen collected: Austin, 1727.

SORGHUM.

Bacterial blight (*Bacillus sorghi* Burr.).—This trouble is very generally present on all the varieties of sorghum (*Andropogon sorghum* (L.) Brot.) grown in this section, such as milo maize, Kafir corn, and cane. It produces on the leaves elongated purplish or dark-brown patches quite commonly confluent, so that large portions of the leaf are discolored. Many of the specimens represent mixed infections of *Colletotrichum* spots and bacterial blight.

Specimens collected: Boerne, 1653; New Braunfels, 1691, 1701; Sabinal, 1968; Hondo, 1993; Bastrop, 2020; Lockhart, 2067; Cotulla, 2161, 2203; Seguin, 2298; Stockdale, 2612; Flatonia, 2723; Floresville, 2848.

Head-smut (*Sphacelotheca reiliana* (Kuhn.) Clint.).—The head-smut is not uncommon on the various varieties of sorghum, but is not so generally abundant as the kernel smut.

Specimens collected: San Antonio, 1794; Uvalde, 1926; Bastrop, 2051; San Marcos, 2104; Seguin, 2292; Victoria, 2350; Stockdale, 2636; Gonzales, 2701; Hallettsville, 2799.

Kernel smut (*Sphacelotheca sorghi* (Lk.) Clint.).—The smut was present in the majority of fields examined.

Specimens collected: New Braunfels, 1700; Llano, 1750; San Antonio, 1795; Uvalde, 1925; Sabinal, 1978; Hondo, 1991; Bastrop, 2052; Luling, 2249; Seguin, 2294; Victoria, 2500; Gonzales, 2702.

Leaf-blight (*Helminthosporium turcicum* Pass.).—Very large irregular areas frequently appear on the leaves. They are usually brown with a narrow border of reddish purple. Quite commonly they have a tendency to be formed on the leaf margin or to advance from the leaf tip, so that large portions become involved. Isolated central spots may be found. An *Alternaria* was very commonly associated with this fungus.

Specimens collected: Sabinal, 1971; Luling, 2237; Falfurrias, 2493; Stockdale, 2638.

Leaf-spot (*Colletotrichum lineola* Cda.).—This disease is characterized by the formation of numerous oval spots, 1 to 5 mm. in length, with pink center and reddish-purple border, which becomes red on the outer border. The pink centers show the black acervuli in groups, or even a single acervulus, but in many cases acervuli may be entirely absent. The spots may become very abundant and confluent and kill the leaf generally from the tip back. The dead portion turns brown and the affected spots show as darker areas. (Pl. XI, fig. 2.) The disease was very abundant and severe in some localities.

Acervuli black, amphigenous; setæ 75 to 150 by 4.5 to 6 μ , base enlarged, very dark throughout, many septate, pointed and generally showing a marked constriction at some point above the base; basidia short, 15 to 20 by 3 to 6 μ , hyaline (Pl. VI, fig. 13); spores falcate, hyaline, granular or guttulate, and 20 to 30 by 4 to 6 μ (Pl. VI, fig. 14).

Our specimens are doubtfully referred to *C. lineola*. They are similar to many of the specimens which American mycologists have assigned to this species. It seems, however, that *C. lineola* Cda. and *C. andropogonis* Zimm. have not been clearly differentiated. (See footnote under "Johnson grass," p. 52.)

Specimens collected: Skidmore, 2806; Victoria, 2349; Nursery, 2564; Kerrville, 1586; Beeville, 1865; Gonzales, 2703; Yoakum, 2754.

DISEASES OF FIBER PLANTS.

COTTON.

Angular leaf-spot (*Bacterium malvacearum* Erw. Sm.).—The angular leaf-spot of cotton (*Gossypium herbaceum* L.) was observed in the great majority of fields examined. Pellucid spots were observed on

the bolls in several cases either in connection with anthracnose or distinct from it, which are probably due to the same bacterium.

Specimens collected: San Antonio, 1410; Boerne, 1637; Beeville, 1822; Elgin, 1883; Bastrop, 2045; Lockhart, 2066; San Marcos, 2094; Sabinal, 1974; Hondo, 1994; Luling, 2240; Seguin, 2301; Georgetown, 2386, 2387; Round Rock, 2414; Victoria, 2348; Nursery, 2543; Cuero, 2584; Stockdale, 2613; Gonzales, 2680; Flatonia, 2726; Yoakum, 2759; Hallettsville, 2797; Falfurrias, 2436, 2438.

Anthracnose (*Glomerella gossypii* (South.) Edgerton, 12).—The anthracnose of the cotton bolls is not very abundant in this territory. Bolls were collected which showed only one or two small sunken anthracnose spots, while others were nearly completely covered. No fields were observed where the disease was sufficiently abundant to cause any material injury.

Specimens collected: Bastrop, 2050; Lockhart, 2079; Luling, 2280; Seguin, 2331; Victoria, 2517; Stockdale, 2639; Gonzales, 2708; Yoakum, 2772.

Leaf-spot (*Cercospora gossypina* Cke.; *Sphaerella gossypina* Atk.).—Only the *Cercospora* stage of this fungus was observed. The spore size ranges from 70 to 150 by 3 to 4 μ , which is in excess of the measurements recorded by Saccardo (45). This disease is not as abundant in this territory as the angular leaf-spot and affected leaves are not as seriously injured.

Specimens collected: Sabinal, 1973; Luling, 2261; Victoria, 2344; Alice, 2495; Nursery, 2573; Gonzales, 2661; Flatonia, 2715; Skidmore, 2801; Kennedy, 2840.

Leaf-spot (*Macrosporium* sp.?).—A leaf-spot of cotton was obtained in a single locality which differed from the angular leaf-spot or the *Cercospora* spot. It is characterized by the presence of numerous brown spots, 3 to 5 mm. in diameter, which show more or less concentric zonation. The tissue adjacent to the spots is frequently colored a pronounced purple. The fungus present is apparently a *Macrosporium*, but the spores are much larger than those of *Macrosporium nigricantium* described by Atkinson (1).

The spores of our species are 90 to 150 by 12 to 16 μ , long-stipitate, the stipe equaling the body of the spore in length; spore cells uniseriate or muriform, constricted at cross partitions, body cells 4 to 7, pale brown.

Specimen collected: Nursery, 2542.

Texas root-rot (*Ozonium omnivorum* Shear).—The common root-rot of cotton is prevalent throughout the entire extent of this territory. In some fields 25 to 75 per cent of the plants were killed. In this connection it may be noted that the same fungus has been collected on the following hosts in addition to cotton: Alfalfa, althæa, bean, black locust, cowpea, fig, okra, parsley, and umbrella China tree.

Specimens collected: Boerne, 1633; Beeville, 1823; Elgin, 1884; Bastrop, 2035; Lockhart, 2068; San Marcos, 2095; Sabinal, 1966; Hondo, 1992; Luling, 2238;

Seguin, 2295; Georgetown, 2388; Victoria, 2342; Cuero, 2583; Stockdale, 2646; Gonzales, 2683; Flatonia, 2727; Yoakum, 2760; Hallettsville, 2798; Falfurrias, 2450, 2466; Alice, 2497; Skidmore, 2499.

Root-rot.—This is a new disease, which is characterized by the dying of the affected plants, the dead plants exhibiting much the same general appearance as in the case of the well-known Texas root-rot. The patches may be small or they may reach nearly an acre in extent. A few plants may persist within the affected areas. At the circumference of the area of dead plants may be found living plants which are affected with the disease, but have not yet succumbed. These diseased plants show frequently a slight chlorosis of the foliage and a diseased condition of the root; others that are affected will show about normal foliage, and the only indication of the presence of the disease is the abnormal condition of the root. Many of these affected plants may wilt down and die in the course of a few hours.

The roots of diseased plants show a marked constriction at the crown, and the root remains apparently smaller from that point downward. An examination of the surface shows many delicate brown hyphæ aggregated in strands or making loosely interwoven masses; numerous small wartlike pustules also appear on the main root as well as on the branches. These wartlike nodules are sclerotal aggregates of fungous tissue which are slightly protruding from the cortex (Pl. XI, fig. 3).

The mycelium shows some *Rhizoctonia* characters, and fruits were found in the field in two cases, which may be connected with the fungus present. The systematic position of the fungus has not yet been determined, but cultural work is in progress which should throw light upon its relationship. The cultures up to the present time have failed to produce spores upon any media, but cultural characters show that the fungus is not a *Rhizoctonia*.

Specimens collected: Falfurrias, 2433, 2434, 2466.

Rust (*Aecidium gossypii* Ell. and Ev.).—The spots produced by this fungus show on the upper surface of the leaf as circular or subcircular areas, 3 to 5 mm. in diameter, with reddish-purple or dark-brown centers, slightly depressed and surrounded by a narrow zone of yellow or orange. The under surface of the spot is slightly hypertrophied and contains numerous cluster cups, 150 to 260 μ in diameter, which have a bright yellow or orange color. From one to three or four spots occurred on a single leaf. While the fungus was general throughout the fields where it was observed, it was not abundant, and caused but little injury. This fungus was first reported from California (22) and no records of its occurrence in other parts of the United States have been found.

Specimens collected: Falfurrias, 2435, 2452.

Sore-shin (*Corticium vagum* B. and C. var. *solani* Burt).—No field notes are at hand regarding the extent of the losses caused by this organism upon the young plants. It is probably generally present and the cause of a very considerable loss in warm, rainy springs.

Specimen collected: Austin, 2895.

DISEASES OF TREES AND SHRUBS.

ALTHÆA.

Root-rot (*Ozonium omnivorum* Shear).—The fungus which causes this trouble on althæa (*Hibiscus syriacus* L.) is the same as the one which produces the root-rot of cotton. The attendant symptoms are essentially similar. The disease was observed only in nurseries, where it killed all the plants in certain sections of the nursery rows.

Specimens collected: Austin, 1924; New Braunfels.

ASH.

Leaf-spot (*Cercospora fraxinites* Ell. and Ev.).—The spots caused by this fungus on the leaves of ash (*Fraxinus* spp.) are subcircular or somewhat irregular, dark gray above, with many minute black heaps of conidia and conidiophores, and are margined by a zone of brown fading out into the green tissue which may show a certain amount of chlorosis; the affected areas are pale brown below with a slightly darker, definite margin, and show fewer and less conspicuous conidial tufts. The spots are 4 to 10 mm. in diameter. Sometimes they are confluent, causing larger dead areas along the margins of the leaflets or removed from the margin. It is stated in the original description of this species (16) that the spots are 3 to 4 mm. in diameter, but the agreement of spore measurements and other characters indicate that our species is *C. fraxinites* Ell. and Ev.

At the time specimens were collected, September 1, little or no defoliation had resulted, but nearly all leaves were affected, each leaflet showing 1 to 13 spots.

Specimen collected: Victoria, 2340.

Leaf-spot (*Cylindrosporium viridis* Ell. and Ev.).—On the upper surface of the leaf the numerous spots are dark purple in color, ranging in diameter from 1 to 4 mm. with a definite margin. The affected areas are more dilute on the under surface, often brownish, and concealed in part by the abundant heaps of white or pinkish spores. The acervuli are immersed, globular or somewhat flattened, 150 μ or less in diameter, and become erumpent only on the lower surface.

According to the original description (19) the acervuli are from three to six in number on each spot and open above. The spores

are cylindrical, fusoid, 30 to 36 by 3 to 4 μ . This measurement of width is in excess of the original description (2.5 μ).

Where the spotting is abundant the leaves become yellow and fall.

Specimen collected: Gonzales, 2652.

Leaf-spot (*Septoria submaculata* Wint.).—As a result of the attacks of this fungus definitely margined spots 1 to 2 mm. in diameter are formed. In the early stages they are circular and purple with a whitish center; later they become brown and angular, 3 to 4 mm. in diameter and are limited by the veins of the leaf.

On the upper surface are black pycnidia, embedded in the leaf tissue. The spores are 20 to 30 by 1 to 2 μ , hyaline and cylindrical.

Although the leaves were abundantly spotted, no defoliation was seen.

Specimen collected: Austin, 1546.

BLACK HAW.

Leaf-spot (*Hendersonia foliorum* Fekl. var. *viburni* Sacc.).—This fungus produces angular spots, 2 to 5 mm. in diameter upon the leaves of the black haw (*Viburnum prunifolium* L.) The pycnidia are sparsely scattered over the upper surface of the spots which are gray or dirty yellow with a darker border. The spots may be few in number on each leaf, or as many as 15.

Specimen collected: Austin, 331.

BLACK LOCUST.

Leaf-spot (*Cylindrosporium solitarium* Heald and Wolf, 32).—This disease of black locust (*Robinia pseudacacia* L.) is characterized by the presence of minute brown spots upon the leaflets. In the early stages of the disease the leaflets have their normal green color, and the spots show as circular areas, 0.5 to 1 mm. in diameter, which have a pale-brown center and a narrow, darker brown border, surrounded by a faint zone of chlorotic tissue. As the disease progresses the entire leaflet turns to a bright-yellow color with the exception of narrow zones of pale green which persist around the circumference of the brown spots. In this stage the spots show an outer zone of green, a middle zone of dark brown, and a central area of light-brown or grayish tissue. (Pl. XIII, fig. 4.) Affected leaflets may show from 1 to 40 spots, and these are generally isolated, although they may be somewhat clustered. The leaflets fall soon after they assume the yellow color and sometimes even before the complete chlorotic stage has been reached. In many cases considerable defoliation results.

Each spot shows one and occasionally two acervuli, which occupy the middle of the light-brown, central area. A straight or curved mass of spores may be seen extruded from the acervulus, which is immersed in the tissue of the under surface. The spores are 45 to 60 by 3 to 4 μ , 3 to 6 septate, generally slightly curved, nearly cylindrical but sometimes tapering, and hyaline. (Pl. VI, fig. 4.)

The disease was observed during the season of 1908 in a much more severe form than in 1909. In all cases it was observed only on nursery trees which were badly crowded.

Specimens collected: Austin, 459, 1909 (type specimens); Georgetown, 2354.

Root-rot (*Ozonium omnivorum* Shear).—This disease was found in a nursery where it had destroyed a small group of young trees (5 or 6 years old). The disease had spread across all of the rows and when observed was advancing along the rows. Roots removed from the soil showed the characteristic yellowish-brown filaments.

Specimen collected: Georgetown, 2351.

BOX.

Leaf-blight (*Macrophoma candollei* (B. and Br.) Berl. and Vogl.).—The leaves of box (*Buxus sempervirens* L.) become entirely dry, with scattered black pycnidia 250 to 300 μ in diameter on both surfaces. The conidia are 36 to 40 by 10 to 11.5 μ , hyaline, and densely granular.

Specimens collected: New Braunfels, 1666; Georgetown, 2357.

BOX ELDER.

Leaf-spot (*Gloeosporium negundinis* Ell. and Ev.).—As a result of the attack of this fungus on box elder (*Acer negundo californicum* (T. and G.) Sarg.), circular or subcircular straw-colored spots 3 to 5 mm. in diameter are formed. Most commonly they are so abundant as to result in the formation of larger dead areas, due to the fusion of spots. The yellow color is more pronounced on the under surface.

The acervuli are 125 to 200 μ in diameter, brown or blackish, and more abundant on the upper surface. The spores are oval, guttulate, and 15 to 20 by 5 to 7 μ . *G. negundinis* Ell. and Ev. on the twigs of the box elder, as determined from measurements of spores from specimens in the mycological herbarium of the Bureau of Plant Industry, shows a range of spore size from 5.9 to 6.6 by 16.5 to 19 μ .

Specimen collected: Lockhart, 2060.

Leaf tip-blight (*Septoria marginata* Hald and Wolf, 32).—The tips and margins of the leaves are killed, the dead areas being brick red, light brown to straw colored, or nearly gray in some cases, and confined to a narrow zone at the leaf tip or margin, or extending

back until nearly the whole leaflet is involved. The advancing edge of the affected area is bordered by a narrow zone of yellow.

The pycnidia are very abundant, brown or black, on both surfaces, in surface view subcircular or somewhat irregular, 87 to 140 μ , flask shaped, with a slightly protruding ostiole. Spores clear, 40 to 60 by 2.5 to 3 μ , straight or slightly curved, three to several septate.

The spore measurements are identical in size with *Cylindrosporium negundinis* Ell. and Ev. (21), and the fungus was first referred to this species by the writers, since the extrusion of the spores from the pycnidia simulated acervuli in external appearance. An examination of type specimens shows that the two species are distinct.

This disease results in considerable defoliation, giving the tree the appearance of having suffered from drought.

Specimens collected: Beeville, 1859; Lockhart, 2060; San Marcos, 2113 (type specimen); Luling, 2279; Seguin, 2286; Austin.

BUCKEYE.

Leaf-blight (*Phyllosticta aesculi* Ell. and Martin).—Leaves of the buckeye (*Aesculus octandra* Marsh) affected by this fungus have large marginal areas of yellowish-brown or brown tissue with a region of yellow toward the advancing edge so that the spots are not definite margined. The pycnidia are very numerous on the lower surface and few on the upper surface. In the original description (24) they are said to be hypophyllous. They are minute, measuring from 40 to 50 μ , dark, and contain an abundance of oblong, hyaline spores 3 to 4 by 1 μ .

Apparently it is the cause of a complete defoliation of the trees in the middle of summer. It was collected in only two localities, but it was observed in several other places.

Specimens collected: Seguin, 2307; Austin, 3128.

BUMELIA.

Leaf-spot (*Cercospora lanuginosa* Heald and Wolf, 32).—This disease on *Bumelia lanuginosa* Michx. first appears as indefinite-margined dark-brown spots on the upper surface of the leaf. At length these areas become 1 to 3 mm. in diameter, irregular in outline, with a definite brown margin and a grayish center. Owing to the woolly coating on the lower leaf surface, the leaf spots show through only faintly as brown spots. Scattered over the upper surface of the spot are very dense clusters of conidiophores, 15 μ in length. The spores are cylindrical to slightly clavate, pale smoky, 45 to 54 by 5 μ , and three to four septate. (Pl. II, fig. 2.)

Specimens collected: Luling, 2222 (type specimen); Flatonia, 2742.

Leaf-spot (*Phyllosticta bumeliifolia* Heald and Wolf, 32).—This causes the formation of definite, pale-brown spots on the leaves. These spots vary in diameter from 3 to 6 mm. when circular or sub-circular, but often the areas have fused so that much larger, irregular spots are produced. The color is less intense on the lower surface. Numerous black pycnidia, ranging from 125 to 150 μ , open to the upper surface. The spores are globular, granular, with one or more guttulæ, 9 to 15 μ in diameter. In severe cases half of the leaf tissue may be involved.

Specimens collected: Austin, 1549 (type specimens); 3032.

Sooty mold (*Fumago vagans* (?) P.).—The interlacing filaments give the effect of a black crust on the entire upper surface of the leaf.

Specimen collected: Austin, 253.

BUTTONBUSH.

Leaf-spot (*Ramularia cephalanthi* (Ell. and Kellerm.) Heald).—This fungus on the buttonbush (*Cephalanthus occidentalis* L.) produces numerous circular, brown spots 0.5 to 2 mm. in diameter, surrounded by a narrow, slightly elevated, darker brown border, which is in turn surrounded by a zone of bright red, 1 to 2 mm. wide, irregular margined, and fading out into the green. The spots are uniformly brown on the under surface. Conidia are produced only when the brown centers become somewhat gray. The spots may be very abundant and become confluent, causing the death of large areas of the leaf, or considerable chlorosis may precede the browning.

The size of the spores and the general symptomatology indicate that the fungus is *Cercospora cephalanthi* Ell. and Kellerm. (23), but the formation of the spores in chains (Pl. V, fig. 4) places it with *Ramularia*. Our specimens show spores which are apparently mature, 18 to 30 by 3 μ , and hyaline or faintly smoky. The change in size and color given for mature specimens (17) is probably based on the examination of a true *Cercospora*.

Specimens collected: Uvalde, 1930; Cotulla, 2148.

Leaf-blight (*Cercospora perniciosa* Heald and Wolf, 32).—When this disease is present the entire foliage of the tree is seriously affected. Isolated spots are about 1 cm. in diameter, reddish brown, with a darker border. Often the spots have narrow rings of this darker brown tissue, rendering them zonate.

Most commonly these spots are irregular in outline, as the diseased areas have fused, causing a large part of the leaf to become dry. The lower surface of the leaf is much more dilutely colored. On the upper surface the profusion of conidiophores and conidia renders the spots grayish. The conidiophores are densely fasciculate, clear or dilutedly colored, 40 to 50 by 3 to 4 μ . The spores are clavate,

guttulate, 45 to 105 by 3 to 4 μ , and obscurely septate. (Pl. III, fig. 3.)

Where the disease has been observed the trees were almost entirely deprived of their leaves.

Specimens collected: Victoria, 2539 (type specimens); Austin, 2869.

CAPE JASMINE.

Sooty mold (*Fumago vagans* (?) P.).—The upper surface of the leaves of the Cape jasmine (*Gardenia jasminoides* Ellis) is entirely covered by a black, filmy crust. Plant lice were also present.

Specimen collected: Austin, 216.

CATALPA.

Leaf-blight.—Nursery trees and older trees of catalpa (*Catalpa* sp.) are frequently sufferers from a severe leaf-blight in which a species of *Cercospora* probably plays a secondary part. In some cases irregular, dead, brown areas occur along the margin and extend downward between the prominent radiating veins; or isolated brown spots, small or of considerable size, may occupy a similar position. In some spots the *Cercospora* may be mingled with an *Alternaria*, or *Cercospora* may be the only fungus present, and in one case *Alternaria* with little or no *Cercospora* was observed. In the specimens which showed the most severe development of the disease, with large dead areas involving in some cases nearly half of a leaf, much concentric zonation was characteristic; scattered over the brown, dead areas were numerous subcircular gray or white spots, 1 to 2 mm. in diameter, which produced central conidiophore tufts on both surfaces.

Conidiophores densely clustered, brown, becoming lighter toward the apex, few septate, irregular nodose tips, 60 to 75 by 3 to 4 μ , with occasional individuals of double the average length. Spores slender clavate, straight or only slightly curved, hyaline, few to many septate, and 42 to 130 by 3 to 4.5 μ .

The *Cercospora* on our specimens differs from *Cercospora catalpae* Wint., especially in having much longer and more slender spores, and also by producing amphigenous conidial tufts, but they should probably be referred to this species.

In the territory covered by this report the species of catalpa make a poor and frequently crippled growth and the foliage shows the effect of excessive transpiration in the early part of the season. The position and characteristics of the dead areas indicate that the trouble is largely physiological and that the fungi present find an easy growth in the dead or languid tissues.

Specimens collected: New Braunfels, 1674, 1681; Luling, 2239; Falfurrias, 2464.

CAT'S-CLAW.

Rust (*Ravenelia versatilis* (Pk.) Diet.).—The affected leaflets of cat's-claw (*Acacia greggii* A. Gray) have minute (scarcely large enough to be noticeable) brown pustules surrounded by chlorotic tissue. The leaflets become yellow and drop off.

Specimen collected: Uvalde, 1957.

CEDAR.

Cedar rust (*Gymnosporangium exiguum* Kern).—This is a new species of *Gymnosporangium* which has recently been described from Texas (35). Previous to the formation of telia on the cedar (*Juniperus sabinoides* Nees) the presence of the infected twigs can be detected only by the brown or yellow cast of the scale leaves. The minute chestnut-brown telia are formed in the month of March or early in April, and protrude from between the scale leaves. (Pl. XVIII, fig. 2.) The affected twigs are killed and are later cast from the tree. The fungus is frequently present in sufficient quantity to give the tree a marked scorched appearance after the telia have matured and disappeared.

Specimens collected: Austin, 754, 855.

Cedar-apples (*Gymnosporangium* (?) *globosum* Farl.).—This species of *Gymnosporangium* produces brown galls varying in size from minute globular enlargements to somewhat nodose structures an inch or more in diameter. The gall is similar to that produced by *G. juniperi-virginianae*, but shows marked depressions between the telial areolæ. The telia are flattened rather than terete, and show pointed truncate or notched apices.

Our specimens were sent to Mr. F. D. Kern, Purdue University, Lafayette, Ind., who referred them to *G. globosum* Farl. The specimens show no indication of a perennial character, and in this respect appear to be quite similar to *G. juniperi-virginianae*, but the spores are similar to those of *G. globosum*.

Specimens collected: Austin, 497, 686, 758, 854.

Whitening of the cedar (*Cyanospora albicedrae* Heald and Wolf).—The mountain cedar is frequently attacked by a fungus (31) which produces extended white patches upon the bark of trunk or branches and upon the surface of branches or twigs which have apparently been corroded by the action of the fungus. The white areas may completely encircle the branches, or they may be confined to one side. Darker oval nodules, 1 to 2 mm. long by about 1 mm. wide, containing the perithecia, are scattered over the whitened areas. Each nodule contains one or more perithecia, which open to the surface by excentrically located ostioles. On the bark these nodules are flat-

tened, while on the twigs from which the cortex has been corroded they stand out more prominently, owing to the fact that the surrounding wood tissue has been more corroded than the wood tissue which constitutes the stromatic nodule. The stromatic nodules on the decorticated twigs are also more nearly black, while those on the bark are dark gray.

This fungus is so constantly present on the mountain cedar that the occurrence of white patches on the bark has been given as one of the characteristics of this species of cedar (3). The fungus which causes this trouble has been under investigation by the writers for some time, and it seems probable that it represents a new and undescribed species and genus. A more detailed consideration has been published in *Mycologia*.

A study of the affected cedars under field conditions indicate that the fungus is a true parasite. Affected trees frequently show a large quantity of dead decorticated twigs and branches.

Specimens collected: Austin, 306, 1434, 2865. Coextensive with the distribution of the mountain cedar.

COTTONWOOD.

Leaf-spot (*Septoria musiva* Pk.).—Numerous small, angular areas are formed on the leaves of the cottonwood (*Populus deltoides* Marsh), which are brown, but may become grayish. The pycnidia, containing hyaline, curved spores 30 to 35 μ long, appear on the upper surface.

Specimens collected: Lockhart, 2076; San Marcos, 2117.

Leaf-spot (*Septoria populicola* Pk.).—This species differs mainly from the above in the fact that the pycnidia open on the lower surface and the spores are 60 to 75 by 3 to 4 μ . The amount of defoliation is only slight.

Specimens collected: Austin, 413, 1423, 1432, 2910; Victoria, 2339; Gonzales, 2856.

Rust (*Melampsora medusae* Thm.).—Observed only in a single locality, where it was causing no serious damage.

Specimens collected: Austin, 162, 414.

GRAPE MYRTLE.

Leaf-spot (*Cercospora lythracearum* Heald and Wolf, 32).—Circular to subcircular indefinite-margined areas appear on the foliage of the crape myrtle (*Lagerstroemia indica* L.). These spots, varying in size from 2 to 8 mm., are uniformly yellowish brown below and dark brown above with a zone of limiting yellow tissue paling out into the green tissue.

The conidiophores are densely clustered, 15 to 20 by 3 μ , continuous, diluted brown in color, and are present on both surfaces, mostly epiphyllous, however. The spores are 30 to 42 by 3 μ , 4 to 5 septate, clavate or subcylindrical, and diluted colored. (Pl. I, fig. 6. See also "Pomegranate".)

Specimen collected: Austin, 486 (type specimen).

Leaf tip-blight.—This trouble begins as a drying of the leaf tips, which become brownish in the dead portions. An extended zone of chlorotic tissue gradually fading into the green marks the advancing edge. The entire leaf may become dry and fall, exhibiting all the appearances of a physiological trouble. Three fungi (*Phyllosticta lagerstroemia* Ell. and Ev., *Pestalozzia guepini* Desm., and *Cercospora lythracearum* Heald and Wolf) were present.

Specimens collected: Beeville, 1857; Flatonia, 2748; Luling, 2254.

DOGWOOD.

Leaf-spot (*Cercospora cornicola* Tracy and Earle).—Very abundant, indefinite-margined, irregular, brown spots are formed on the foliage of the dogwood (*Cornus* sp.). The margin is quite commonly purplish. The entire foliage becomes seriously affected.

Specimens collected: Austin, 351; San Antonio, 1778; San Marcos, 2107; Seguin, 2304; Victoria, 2534; Gonzales, 2706; Flatonia, 2749; Hallettsville, 2788, 2795.

ELDERBERRY.

Leaf-spot (*Cercospora catenospora* Atk.).—The spots on the leaves of elderberry (*Sambucus canadensis* L.) caused by this fungus are yellow at first, becoming gray with age. They are rounded or elongated in the direction of venation and 3 to 6 mm. in greatest length. They are often so numerous as to be confluent, resulting in the chlorosis and subsequent fall of the foliage.

Specimen collected: San Marcos, 2114.

ELM.

Blight.—The small-leaved elms (*Ulmus* spp.) frequently show a blight or scald of the foliage which is characterized by the death of the leaf tips. The dead, brown area advances downward until the whole leaf may be involved. The brown area is generally bordered by a zone of chlorotic tissue. In some cases the dead areas are not terminal or marginal, but show as definite spots. This is true for our specimens of *Ulmus crassifolia*. In some cases an *Alternaria* is present, but it is not sufficiently constant to be definitely connected with the disease.

Specimens collected: (1) On *Ulmus alata* Michx.—Gonzales, 2699; Kennedy, 2823. (2) On *U. crassifolia* Nutt.—New Braunfels, 1719.

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Leaf-scab (*Gnomonia ulmea* (Sacc.) Thm.).—Elm leaves affected with this fungus show minute spots scattered over the surface. These spots, which are 1 to 3 mm. in diameter, show on the upper surface a central cluster of small black pustules surrounded by a border of dead tissue, white or gray in color; or the black pustules may be somewhat concentrically arranged. In the early stages of development the spot will not be noticeable on the under surface, but in the later development the under surface shows a definite brown area of dead tissue opposed to the white zone of the upper surface. In this stage the epidermis of the under surface is elevated in numerous pustules and ruptured to some extent by the protruding beaks of the perithecia. The late fall collections show only immature perithecia. The white zone bordering the perithecial pustules is caused by the accumulation of large quantities of crystals in the epidermal cells (Pl. XIII, fig. 1).

In many of the collections, especially upon the late collections of *Ulmus alata*, a *Coniothyrium* is present. The pycnidia of this fungus may be present on either surface of the spots and produce an abundance of oval, brown spores 3.5 to 4 by 6 μ . It is possible that this represents a pycnidial stage of the *Gnomonia*, but proof of a definite connection must be obtained by cultures. It may be noted in this connection that a *Phoma*-like pycnidium has been observed in connection with *Phomatospora* (25), a genus belonging to the *Gnomoniaceæ*.

Some specimens of *Ulmus alata* show a third type of fruit. These fruits show as minute erumpent papillæ scattered abundantly over the under surface, while the upper surface shows a marked yellow punctate appearance. The spores produced are two to three septate, 21 to 39 by 4 μ , and hyaline. These spores may be the only form present on the leaves at a given time, or they may be found in connection with the perithecial stage of *Gnomonia*. These spores and pycnidia show a marked similarity to *Phleospora ulmi* (Fr.) Wallr. (36), and it seems probable that they represent a stage in the life history of our *Gnomonia*, since Klebahn (36) has proved a similar connection between *Phleospora ulmi* (Fr.) Wallr. and *Mycosphaerella ulmi*, another genus of the *Sphaeriales*.

Specimens collected: (1) *Ulmus alata* Michx.—Austin, 255, 256, 338; Llano, 1749. (2) *Ulmus crassifolia* Nutt.—New Braunfels, 1675; Uvalde, 1928; Seguin, 2812; Elgin, 1874. (3) *Ulmus americana* L.—Round Rock, 2419.

Leaf-spot (*Cylindrosporium tenuisporum* Heald and Wolf, 32).—The small-leaved elm is affected by a leaf-spot which shows as brown circular or slightly irregular areas, 2 to 10 mm. in diameter, generally with a gray center and a narrow yellow border. The under surfaces of the spots are more uniformly brown and show minute black specks,

the acervuli of the fungus. In a few cases the acervuli may be found on the upper surface.

The spores are very narrow, cylindrical, hyaline, continuous, straight or slightly curved, 15 to 24 by 0.75 to 1 μ .

Specimen collected: On *Ulmus crassifolia* Nutt.—Austin, 307 (type specimen).

Mistletoe (*Phoradendron flavescens* (Pursh.) Nutt.).—The small-leaved elm (*Ulmus crassifolia*) is one of the many trees attacked by mistletoe.

Specimen collected: On *Ulmus crassifolia* Nutt.—Llano, 1737.

Powdery mildew (*Uncinula* sp.).—Powdery mildew was collected in a single locality on the cork-winged elm (*Ulmus alata*). It was found only in the conidial stage and was not abundant. Since two species of *Uncinula* have been described for this host, a definite specific determination can not be made.

Specimen collected: On *Ulmus alata* Michx.—Llano, 1753.

ENGLISH IVY.

Anthracnose (*Colletotrichum gloeosporioides* Penz. var. *hederæ* Pass.).—Irregular, brown, raised, definite-margined areas are formed on the leaves of the English ivy (*Hedera helix* L.). Often they are confined to the tips of the lobes, but at times they are central. The acervuli are formed abundantly over the entire diseased areas.

Specimens collected: San Antonio, 1403; Gonzales, 2685; Flatonia, 2747.

Leaf-blight (*Phyllosticta concentrica* Sacc.).—This disease begins on the leaf tips or centrally and results in the formation of dark-brown, dead areas which may extend until the whole leaf is involved. Some spots have a blackish tinge, due to the numerous pycnidia, which in some cases are arranged so as to show concentric zonation. The spores are ovoid, 10 by 7 μ , hyaline, guttulate, and embedded in a mucilaginous matrix. This blight in one locality was observed to have destroyed about half the foliage; so it is the cause of serious harm.

Specimens collected: Austin, 1313; New Braunfels, 1667; Stockdale, 2637.

Leaf-spot (*Ramularia hedericola* Heald and Wolf, 32).—Large irregular spots, grayish brown above and brown below, appear on the leaves. The margin of the diseased area is elevated, with the fungus fruits on the upper leaf surface. Conidiophores 60 to 120 by 4 μ , septate. Conidia clear, 9 to 15 by 2.5 μ . (Pl. V, fig. 5.)

Specimen collected: San Marcos, 2130 (type specimen).

EUONYMUS.

Anthracnose (*Colletotrichum griseum* Heald and Wolf, 32).—This is one of the most common diseases of *Euonymus japonicus* Thunb. for this region. It forms on the leaves indefinite-margined, yellow blotches 1 to 4 mm. in diameter. These increase in size until the diseased areas are sometimes 8 to 10 mm. across; a definite, brown, elevated border is formed, and the center of the spot becomes gray. Scattered over this gray area are numerous black acervuli, either zonate or more or less scattered, usually concentrically arranged. Often the spots are marginal, or the disease may apparently work back from the tip of the leaf. (Pl. XII, fig. 2.)

The twigs and larger branches are also affected, resulting in the formation of gray cankers 1 to 8 mm. in diameter.

These gray patches drop away, leaving the brown, cankered area exposed. The acervuli are immersed, varying in shape from globular to quite flat, 250 to 300 μ in diameter, the margin of the opening being set with numerous brown setæ, 40 to 60 by 5 μ , quite uniform in diameter or sometimes taper pointed. (Pl. VI, figs. 1, 2.) The spores are straight or only slightly curved, hyaline, densely granular, or with several guttulæ, 14 to 17 by 4 μ , and rarely marked by a single transverse septum which does not divide the cell into equal halves. (Pl. VI, fig. 1.)

Specimens collected: Austin, 1280 (type specimen); San Antonio, 1404; Lockhart, 2110; Georgetown, 2353, 2376.

Leaf-spot (*Exosporium concentricum* Heald and Wolf, 32).—This fungus produces on the leaves circular areas 0.5 to 2 cm. in diameter which may show concentric zonation. This zonation is due to concentric regions of brown and grayish yellow. The acervuli are confined to the grayish-yellow regions. In other cases the spots may be uniformly grayish yellow with a narrow brown border. Usually only one spot is present on each leaf, but occasionally there are several, which fuse. (Pl. XII, fig. 1.) The affected leaves may show considerable yellowing beyond the diseased areas, and in severe cases much defoliation follows.

The acervuli, 100 to 150 μ in diameter, are dark and either concentrically arranged or scattered. They are at first covered and at length protrude, causing that portion of the leaf to become grayish because the rupture of the epidermis has admitted the air. The spores are nearly hyaline, clavate cylindrical, 25 to 45 by 2.5 to 3 μ , one to several septate. (Pl. VII, fig. 5.)

Specimens collected: San Marcos, 2129; Georgetown, 2375; Austin, 2867 (type specimen).

HACKBERRY.

Leaf-spot (*Cylindrosporium defoliatum* Heald and Wolf, 32).—The common hackberry of this region (*Celtis laevigata* Willd.) is quite generally affected with a serious leaf blight which first produces irregular gray blotches 1 to 2 cm. in diameter. These blotches sometimes coalesce and involve a large part of the leaf. (Pl. XIV, fig. 1.) In early stages of the disease the adjacent leaf tissue may remain green, but later a considerable amount of yellowing is produced, and the affected leaves fall from the tree.

The acervuli are amphigenous, but more abundant upon the upper surface, 60 to 75 μ , immersed. (Pl. VI, fig. 10.) The spores accumulate on the surface of the leaf, where they are visible as minute white tufts. The spores are hyaline, cylindrical, straight, or curved, 30 to 42 by 3 to 3.5 μ , and three to five septate. (Pl. VI, fig. 9.) This species is clearly distinct from *Cylindrosporium celtidis* Earle, which has been described as forming small spots on *C. laevigata* in Alabama (11).

Specimens collected: (1) On *Celtis laevigata* Willd.—New Braunfels, 1673; Austin, 1728, 1905 (type specimen); Elgin, 1890; Bastrop, 2049; Lockhart, 2073; San Marcos, 2099; Cotulla, 2180; Luling, 2256; Seguin, 2317; Georgetown, 2377; Victoria, 2509; Cuero, 2578; Stockdale, 2615; Gonzales, 2689; Flatonia, 2709; Yoakum, 2771. (2) On *Celtis reticulata* Torr.—Beeville, 1855; Sabinal, 1975.

Leaf-spot (*Ramularia celtidis* Ell. and Kellerm.).—Very numerous small white spots form on the leaves. They are circular in outline and about 2 mm. in diameter. The margin is brown or yellow and slightly raised.

Specimens collected: (1) On *Celtis reticulata* Torr.—Austin, 464; Beeville, 1814; Luling, 2265; Gonzales, 2690; Kennedy, 2835. (2) On *C. laevigata* Willd.—Austin, 1539; Lockhart, 2062; Georgetown, 2355; Hallettsville, 2779.

Mistletoe (*Phoradendron flavescens* (Pursh.) Nutt.).—This parasitic plant is present on the hackberry throughout the territory covered by this survey. It is often so abundant that the winter aspect makes the tree appear in full foliage.

Powdery mildew (*Uncinula polychaeta* B. and C.).—The mycelium forms a white, felty coating on both leaf surfaces, generally forming patches and not covering the entire leaf.

Specimens collected: On *Celtis reticulata* Torr.—Austin, 415; Georgetown, 2392; Cuero, 2587.

HAWTHORN.

Blotch (*Hendersonia foliorum* Fckl.).—On the leaves of the hawthorn (*Crataegus* spp.) large, brown, irregular blotches appear, and on these blotches black dots (the pycnidia) are formed. Each

pycnidium contains brown spores, 15 by 6 μ , and three septate. It is probably merely associated with a physiological languor, coming in as a saprophyte.

Specimen collected: Gonzales, 2698.

Leaf-spot (*Cercospora crataegi* Heald and Wolf, 32).—This fungus causes the formation of large, dark-brown, irregular areas from 5 to 10 mm. or more in diameter. The spots are darker above than below, and when as many as 20 to 25 in number are confluent, involving large areas, with chlorotic tissue surrounding them. The upper surface is broken by the numerous brown tufts of conidiophores and conidia. The conidiophores are closely aggregated, 24 to 30 by 5 to 6 μ , brown and nonseptate. The conidia are clavate, straight or curved, 120 to 180 by 5 to 7 μ , many septate with prominent guttulæ. (Pl. IV, fig. 2.)

Specimen collected: Gonzales, 2697 (type specimen).

Rust (*Gymnosporangium globosum* Farl.).—The cluster cups of this rust were found abundantly present on the leaves and twigs of *Crataegus crus-galli* L. (See under "Cedar.")

Specimens collected: Austin, 1312, 1444 (cluster cups).

Rust (*Gymnosporangium* sp.).—Several species of *Crataegus* have been found whose leaves are covered by reddish-yellow areas, with a group of black spermagonia at the center.

Specimens collected: Elgin, 2009; Lockhart, 2069.

HEMP TREE.

Leaf-spot (*Cercospora viticis* Ell. and Ev.).—Irregular, suborbicular, rusty spots, 2 to 4 mm. in diameter are formed on the hemp tree (*Vitex agnus-castus* L.). The margin of the area is elevated and darker, with a paler center as the spots become old.

Specimen collected: Nursery, 2569.

JAPANESE IVY.

Leaf-spot (*Phyllosticta labruscae* Thm.).—The spots produced on the Japanese ivy (*Pseodera tricuspidata* (Sieb. and Zucc.) Rehder) by this fungus are subcircular, 5 to 8 mm. in diameter, reddish brown, with a narrow dark border. The black pycnidia open to the upper surface.

Specimen collected: Austin, 3103.

LILAC.

Leaf-blight (*Cercospora macromaculans* Heald and Wolf, 32).—This blight on the lilac (*Syringa* sp.) is characterized by the pres-

ence of large, brown, dead patches 1 cm. or more in diameter, which are more or less irregular and either central or marginal. The center of the spots is frequently gray, and sometimes an evident zonation is exhibited, due to the concentric arrangement of the dark conidial tufts.

Conidiophores amphigenous, densely fasciculate, many septate, dark brown, 60 to 75 by 6 μ ; spores slender clavate, tapering gradually to the end, few to many septate, hyaline, 70 to 187 by 2.8 to 3 μ . (Pl. I, fig. 7.)

This blight causes the death of many leaves and much defoliation.

Specimens collected: Austin, 463, 1910; Kerrville, 1803 (type specimen).

Powdery mildew (*Microsphaera alni* (Wallr.) Wint.).—The lilac is only rarely used in this region as an ornamental shrub, and so the mildew is not common.

Specimen collected: Austin, 1308.

LIPPIA.

Leaf-spot (*Cylindrosporium lippiae* Heald and Wolf, 32).—This fungus produces on lippia (*Lippia ligustrina* (Lag.) Britton) three to four circular spots 2 or 3 mm. in diameter to each leaf. The spots have gray centers with narrow brown borders edged with a tinge of yellow, and show in the center numerous white conidial tufts.

Acervuli amphigenous, 30 to 100 μ in diameter, more on the upper surface; spores hyaline, straight or generally curved, continuous or one to three septate, 24 to 54 by 3 μ , nearly cylindrical. (Pl. VI, fig. 5).

Specimen collected: Llano, 1756 (type specimen).

MAGNOLIA.

Leaf-spot (*Coniothyrium olivaceum* Bon. var. *grandiflorae* Sacc.).—This fungus on the magnolia (*Magnolia grandiflora* L.) occurs on circular or subcircular, definite-margined spots, 1 to 5 mm. in diameter, which are yellowish brown above with a narrow limiting zone of darker brown and uniformly brown on the under surface, but of a darker shade. There may be from a few to a dozen or more spots to each leaf, but the fungus is not responsible for any defoliation.

The pycnidia are on the lower surface and are uniform in color with the spot, and consequently are not visible to the naked eye. They are globular, 100 μ in diameter, which is much less than the recorded size (300 to 350 μ), but the spores are of similar dimensions.

Specimen collected: Georgetown, 2374.

MAPLE.

Leaf tip-blight (*Gloeosporium* sp.?).—The maple (*Acer saccharinum* L.) is not indigenous to this section, and occurs only rarely

under cultivation. This leaf disease causes a browning of the tips of the lobes. The acervuli are sparsely present on the lower surface. We were unable definitely to associate this fungus with any of the ten species described as occurring on species of *Acer*.

Specimens collected: Victoria, 2520; Flatonia, 2716.

MESQUITE.

Anthracnose (*Gloeosporium leguminum* (Cke.) Sacc.).—The pods of the mesquite (*Prosopis glandulosa* Torr.) are quite generally affected by a *Gloeosporium*, which produces irregular slightly sunken areas on one side of the pods or completely encircling them. The spots show numerous black acervuli, which are generally aggregated and frequently confluent on a gray ground, and the whole area is surrounded by a narrow zone of brown. Seriously affected pods fall from the tree before they reach maturity.

Specimens collected: Austin, 17; San Antonio, 1360; Beeville, 1796; Elgin, 1891; Uvalde, 1961; Hondo, 1996; Bastrop, 2046; Lockhart, 2061; San Marcos, 2096; Cotulla, 2184; Luling, 2253; Seguin, 2314; Stockdale, 2609; Gonzales, 2662; Floresville, 2843.

Blight.—The affected leaves in the early part of the growing season show a pronounced yellow color on the upper surface, while large numbers of minute yellowish heaps cover the under surface. The affected leaves soon fall, and by midsummer they have entirely disappeared. Thus far it has been impossible to associate the trouble with any known organism.

Specimens collected: San Marcos, 926; Austin, 1065.

Galls.—The large limbs and smaller branches of the mesquite sometimes show abnormal enlargements which are frequently globular or sometimes elongated and sometimes greatly exceed the diameter of the branch on which they are produced. (Pl. XV, figs. 2 and 3.) Specimens have been obtained ranging from 1 to 8 or 10 inches in diameter. The gall is produced by an abnormal growth of the wood, and cross sections of galls always show small brown specks where the wood cells are more or less disintegrated. These are distributed throughout the entire woody region.

These galls are not of insect origin, and cultural work attempted has as yet failed to connect either bacteria or fungi with the disease, although both have been obtained.

Specimens collected: Austin, 1294; Llano, 1746; Beeville, 1858; Cotulla, 2218; Runge, 2923.

Mistletoe (*Phoradendron flavescens* (Pursh.) Nutt.).—The American mistletoe is not uncommon on the mesquite. In some regions

having a scarcity of forage it is pruned from the trees and fed to cattle.

Specimens collected: Llano, 1787; Cotulla, 2183; Luling, 2277; Seguin, 2297.

Leaf-blight (*Cercospora prosopidis* Heald and Wolf, 32).—This disease is characterized by the presence of irregular, angular, brown patches which occupy one side of the midrib of the leaflets or extend across the whole leaflet and are generally bounded by a narrow, brown border. The spots may be either terminal or removed from the apex of the leaflets, and they frequently advance until the whole leaflet is killed or drops from the tree. In some cases it is very abundant and causes considerable defoliation. Its greatest development may be found in the dense mesquite thicket.

The conidiophores are amphigenous, densely fasciculate, uniformly brown, continuous, 18 to 30 by 3 to 4 μ ; spores straight, cylindrical to slightly club shaped, brownish, 20 to 70 by 4 to 5 μ , and one to many septate. (Pl. III, fig. 2.)

Specimens collected: Uvalde, 1959 (type specimen); Luling, 2284; Falfurrias, 2468; Gonzales, 2663; Kennedy, 2824; Floresville, 2847.

Powdery mildew (*Erysiphe* sp. ?).—The young mesquites are frequently affected with powdery mildew, but it is rare on older trees. It produces no apparent injury and is abundant only near the end of the growing season. Immature perithecia were found in one locality, but all other collections represent only the conidial stage. Salmon in his monograph does not record a powdery mildew for this host, hence the specific determination can not be made.

Specimens collected: Austin, 200, 2917; Beeville, 1867; Uvalde, 1960; San Marcos, 2091; Cotulla, 2172; Luling, 2278; Seguin, 2315; Falfurrias, 2491; Cuero, 2579; Stockdale, 2610; Gonzales, 2684; Skidmore, 2815; Kennedy, 2837; Floresville, 2841; Hallettsville, 2900.

Rust (*Ravenelia arizonica* Ell. and Ev.).—This rust is very inconspicuous, producing a few minute brown sori on both surfaces of the leaflets. There was no other discoloration of the leaves in the specimens collected. Specimens obtained from a single locality.

Specimen collected: Falfurrias, 2492.

MULBERRY.

Die-back (*Myxosporium diedickei* Syd.).—The branches of young mulberry plants (*Morus* spp.) in the nursery rows were covered with whitish or pink pustules protruding through the epidermis. The terminal portions of the twigs had apparently been killed by this fungus.

Specimen collected: On *Morus alba* L.—Georgetown, 2359.

Eye-spot (*Cercospora moricola* Cke.).—This fungus produces circular or subcircular spots 3 to 7 mm. in diameter on the leaves. The center is tan colored, with a very dark outer zone and outside of this a halo of yellowish brown, paling out into the green. (Pl. XIII, fig. 2.) The conidiophores, densely tufted, pale yellow, 20 to 25 by 3 to 3.5 μ , are on the lower surface. The conidia are clavate, 30 to 75 by 4 to 4.5 μ , slightly colored, two to eight septate, guttulate. (Pl. IV, fig. 6.) This is a common disease on both wild and cultivated forms.

Specimens collected: On *Morus rubra* L.—Llano, 1747; Luling, 2273; Seguin, 2282; Victoria, 2512; Nursery, 2558, 2568; Stockdale, 2607; Hallettsville, 2796.

Leaf-spot (*Cercospora missouriensis* Wint.).—Large, orbicular, dark-brown spots are formed on the leaves. They vary in size from 3 to 7 mm. and usually have a slightly darker border. The conidiophores are borne on the lower surface in dense tufts.

This species is listed by Saccardo (44) under *C. pulvinulata* Sacc. and Wint.

Specimens collected: On *Morus rubra* L.—Austin, 465, 469; Beeville, 1844; Falfurrias, 2459; Cuero, 2597; Floresville, 2842.

Leaf-spot (*Cercospora mori* Pk.¹).—This diseased condition of the foliage is characterized by the formation of irregular, circular or angular spots 1 to 8 mm. in diameter. The areas are brown in color, with a darker border. A conspicuous cushionlike cluster of white or pinkish conidia is extruded near the center, or they may be scattered over the surface of the spots. These acervuli are for the most part on the under surface of the leaf, and are 50 to 100 μ in diameter. The conidiophores are faintly smoky. The conidia are slightly clavate, several septate, hyaline, 35 to 75 by 3 to 4 μ . (Pl. VII, fig. 8.)

Specimens collected: On *Morus alba* L.—New Braunfels, 1684, 1721; Beeville, 1832; Seguin, 2330; Austin, 3184.

OAK.

Ball moss (*Tillandsia recurvata* L.).—This lives epiphytically on the oak (*Quercus* spp.) throughout the entire range except the extreme western and northwestern portions covered by this survey. It is quite commonly considered as parasitic, since it occurs so abundantly and is so apparent on dead trees. Death is probably due to shading of the foliage in addition to edaphic and climatic factors.

Leaf-spot (*Marsonia quercus* Pk.).—The spots, 1 to 2 mm. in diameter, are whitish or grayish brown above and brown below. The areas are often bordered by a narrow purplish zone.

Specimens collected: Elgin, 2008; Victoria, 2502; Stockdale, 2644; Flatonia, 2735.

¹ This fungus has been determined as *Cercospora mori* nov. sp. by Prof. C. H. Peck, to whom specimens were sent for identification.

Spanish moss (*Dendropogon usneoides* (L.) Raf.).—This epiphyte forms long pendent festoons and is very commonly distributed. It is most abundant, however, along the watercourses, while the ball moss is more abundant on the higher ground.

Tar-spot (*Rhytisma erythrosporum* B. and C.).—Thin, black blotches, usually about 4 mm. in diameter, but sometimes as large as 8 mm., are formed on the upper surface of the leaves of the live oak. (Pl. XIII, fig. 3.)

Specimens collected: On *Quercus virginiana* Mill.—Austin, 176, 496, 547, 2936.

OLEASTER.

Leaf-spot (*Cercospora elaeagni* Heald and Wolf, 32).—In this disease the leaves of the oleaster (*Elaeagnus* sp.) show on the upper surface an abundance of circular or subcircular spots 1 to 2 mm. in diameter with a definite brown border and a whitish or brown center. The spots are inconspicuous on the under surface on account of the dense, silvery tomentum. There is generally some yellowing beyond the spot and in many cases a pronounced yellowing of the whole leaf.

Conidiophores amphigenous, densely fasciculate, dark brown, 40 by 3.5 to 4 μ , more abundant on the upper surface; spores clavate, straight or slightly curved, nearly hyaline, 28 to 150 by 2.5 to 4 μ , and one to several septate. (Pl. IV, fig. 4.)

Specimen collected: On imported host (species not known)—Floresville, 2861 (type specimen).

OSAGE ORANGE.

Blight (*Sporodesmium machuræ* Thm.).—No definite spots are produced on the foliage of the Osage orange (*Toxylon pomiferum* Raf.). The under surface acquires a diffuse dirty-brown coloration, not so abundant, however, on the upper surface. Considerable chlorosis accompanies this disease, and a subsequent defoliation results. (Pl. V, fig. 6.)

Specimens collected: Austin, 1922; Seguin, 2319.

Cottony leaf-spot (*Ovularia machuræ* Ell. and Langl.).—This leaf disease is characterized by the cottony appearance of the lower surface of the affected areas. The upper surface of the spots is circular to irregular, rusty brown, and they vary in size from 3 to 10 mm.

Specimen collected: Gonzales, 2894.

PECAN.

Leaf-blight (*Septoria caryæ* Ell. and Ev.).—Some of the trees of the pecan (*Hicoria pecan* (Marsh.) Britt.) in the vicinity of Austin show a large amount of leaf-blight characterized by the presence of large, irregular, chestnut-brown areas on the under surface of the

leaflets, while the upper surface is somewhat paler. The minute black pycnidia are very numerous on the under surface, but are absent from the upper surface. It may be noted that the description of Saccardo (47) gives the pycnidia as amphigenous. There is also a considerable amount of yellowing of the leaf tissue adjacent to the spots, and more or less defoliation results.

Specimens collected: Austin, 238, 2908.

Leaf-spot (*Clasterosporium diffusum* Heald and Wolf, 32).—This fungus produces circular or irregular, indefinite-margined, brown spots, 5 to 10 mm. in diameter, which are uniformly brown on both surfaces of the leaflets.

The fungus produces dark-brown hyphæ which run throughout the dead tissue, or creep over either surface of the affected area, or are sometimes aggregated to produce clusters of erect conidiophores. Spores curved-clavate, many septate, brown, 45 to 135 by 4 to 5 μ (Pl. VII, fig. 4.)

Specimens collected: Victoria, 2536; Gonzales, 2695 (type specimen); Yoa-kum, 2770; Hallettsville, 2783.

Scab (*Fusicladium effusum* Wint.).—This disease first produces minute brown spots on the under surface of the leaflet which increase in size until they reach 3 to 5 mm. in diameter. The spots are circular or subcircular, and in severe infections they may become confluent. In the earlier stages the spots are confined to the lower surface, but finally the leaf tissue is killed and the spot becomes dark brown on the upper surface. It does not show the velvety appearance of the under surface, since the conidiophores are entirely hypophyllous. The scab spots occur also on the petioles.

Specimens collected: Kerrville, 1570; Uvalde, 1927; Seguin, 2309.

POISON OAK.

Rust (*Pileolaria toxicodendri* (B. and Rav.) Arth.).—The small chocolate-brown sori are formed in abundance on the upper surface of the leaves of the poison oak (*Rhus toxicodendron* L.).

Specimen collected: Austin, 347.

POMEGRANATE.

Leaf-spot (*Cercospora lythracearum* Heald and Wolf, 32).—This fungus on the pomegranate (*Punica granatum* L.) produces angular—more or less rounded—brown spots with an indefinite margin below, 1 to 4 or 5 mm. in diameter, sometimes larger. Exceedingly dense aggregates of conidiophores are present on both surfaces, 20 to 30 by 3 μ , clear or only faintly yellowish; conidia clavate, 30 to 56 by 3 to 3.5 μ , clear, septate. (Pl. I, fig. 5.)

This is apparently the same species of *Cercospora* which we have described as causing a leaf spot of crape myrtle (p. 64), a closely related host, and the difference in the conidiophores is no more than might be expected from growth upon different hosts.

Specimens collected: Beeville, 1829; Falfurrias, 2472; Victoria, 2510, 2515; Cuero, 2589; Flatonia, 2738.

PRICKLY ASH.

Rust (*Aecidium xanthoxyli* Pk.).—Cluster cups were found on the leaves of prickly ash (*Zanthoxylum clava-herculis* L.); especially abundant in the vicinity of Austin.

Specimens collected: Elgin, 1872; Austin, 3114.

Sooty mold (*Fumago vagans?* P.).—This forms a sooty coating on the foliage.

Specimen collected: Austin, 419.

PRIVET.

Leaf-spot (*Cercospora adusta* Heald and Wolf, 32.).—This forms on the privet (*Ligustrum* spp.) dark-brown areas involving large spots, frequently extending from the tip downward or from the margin inward. Rarely are the spots removed from the margin. The older diseased parts become very dark and the newer, brown, with a gradual shading out into the chlorotic tissue. Conidiophores 100 to 150 by 4 to 5 μ , brown and septate, appear on both surfaces in small clusters. The conidia are densely granular, clear, multi-septate, and 85 to 160 by 3 to 4 μ . (Pl. III, fig. 1.)

Alternaria is abundantly present on the spots, probably as a saprophyte.

Specimens collected: On *Ligustrum ovalifolium* Hassk.—Falfurrias, 2471 (type specimen); Floresville, 2851.

Leaf-spot (*Cercospora ligustri* Roum.).—Somewhat circular or irregular spots, sometimes as large as 7 mm., are formed. They are brown with a grayish center above and brown below. The margin is purplish or darker brown. (Pl. XV, fig. 1.)

Specimen collected: On *Ligustrum japonicum* Thunb.—Austin, 1316.

Leaf-spot (*Phyllosticta ovalifolii* Brun.).—Small circular brown spots 2 or 3 mm. in diameter, with a darker margin, occur on the leaves. The black pycnidia are few in each area.

Specimen collected: On *Ligustrum ovalifolium* Hassk.—San Antonio, 1405.

REDBUD.

Leaf-spot (*Cercospora cercidicola* Ell.).—In the beginning small brown spots appear on the leaves of the redbud (*Cercis occidentalis* Torr.). These spots become 2 to 4 mm. in diameter, angular, dark brown above and brown below, with a region of yellow tissue sur-

rounding each spot. The leaves become badly spotted, and defoliation results.

Specimens collected: Kerrville, 1621; Austin, 1913; Georgetown, 2397.

RETAMA.

Sooty mold (*Dimerosporium parkinsoniae* Heald and Wolf, 32).—The leaves and smaller twigs and even the smooth bark of larger branches of retama (*Parkinsonia aculeata* L.) are sometimes covered with patches made up of dense aggregates of brown, septate hyphæ.

The conidia are dark brown, one to four celled, and also muriform. (Pl. VII, fig. 2.) The asci are eight spored, 45 to 50 by 12 to 15 μ ; spores hyaline, two celled, lower cell smaller, both biguttulate, and 15 to 18 by 4 to 6 μ . (Pl. VII, fig. 1.)

Specimens collected: Austin, 455; Seguin, 2311 (type specimen); Gonzales, 2658; Hallettsville, 2901.

SUMAC.

Leaf-spot (*Cercospora rhoina* Cke. and Ell.).—Circular or irregular brown or dark-brown, almost black, spots, 3 to 5 mm. in diameter, are formed on the leaves of sumac (*Rhus copallina lanceolata* Gray). They have a tendency to be marginal and extend inward, the outline being angular, due to the veins of the leaf.

Specimens collected: Austin, 218; Georgetown, 2399.

SWAMP CYPRESS.

Leaf-blight (*Pestalozzia funerea* Desm.).—In this disease the leaflets of the swamp cypress (*Taxodium distichum* (L.) Rich.) turn brown. Beginning at the tips, they become brown throughout, or show somewhat grayish, with an abundance of black acervuli. The foliage of affected trees was badly blighted. In one collection showing similar symptoms the *Pestalozzia* was not present, but an *Alternaria* species was found, so it may be possible that the *Pestalozzia* is only a secondary factor in producing the disease.

Specimens collected: Victoria, 2535; Gonzales, 2678.

SYCAMORE.

Blight (*Gloeosporium nervisequum* (Fckl.) Sacc.).—This blight, which is characterized by the formation of dead areas beginning at the margin of the leaf or the tips of the lobes and spreading throughout the leaf, is very destructive to the sycamore (*Platanus occidentalis* L.) in the more humid portion of this territory, but rare in the western and southwestern portion.

Specimens collected: Tyler, 1550; New Braunfels, 1723; Bastrop, 2056; San Marcos, 2118; Georgetown, 2371; Flatonia, 2710; Hallettsville, 2774; Falfurrias, 2470.

Leaf-blight (*Phleospora multimaculans* Heald and Wolf, 32).—Definite, irregular, circular or angular spots, dark brown or purple, and 1 to 3 mm. in diameter, are produced upon the upper surface of the leaves. They frequently show a brown center, and on the under surface the spot is brown throughout with a darker brown border. The spots frequently become confluent and produce dirty-brown, extended, dead areas. The spots may be very numerous, and in nurseries much defoliation results. (Pl. XIV, fig. 2.)

The pycnidia are hypophyllous; spores nearly cylindrical, straight or curved, hyaline, 30 to 50 by 3.5 to 5 μ , and two to three septate, sometimes four septate (Pl. V, fig. 7). (See also Walnut.)

Specimens collected: Austin, 1398, 1535; Brenham, 1462; New Braunfels, 1682 (type specimen); Llano, 1767; Victoria, 2503; Gonzales, 2655; Floresville, 2858.

SYMPHORICARPOS.

Powdery mildew (*Microsphaera diffusa* Cke. and Pk.).—Both the conidial and perithecial condition were abundantly present on *Symphoricarpos orbiculatus* Moench where this was observed. Causes little apparent injury.

Specimen collected: Austin, 1311.

TREE-OF-HEAVEN.

Shot-hole (*Cercospora glandulosa* Ell. and Kellerm.).—This disease on the tree-of-heaven (*Ailanthus glandulosa* Desf.) forms circular spots 1 to 3 mm. in diameter, brown, becoming gray above, with an elevated margin. The whitish conidial tufts are very conspicuous on the lower surface. The entire diseased area at length drops out, producing on the leaves a "shot-hole" effect.

Specimens collected: New Braunfels, 1698; Austin, 2862.

TRUMPET CREEPER.

Leaf-mold (*Cercospora sordida* Sacc.).—On the lower surface of the leaf of trumpet creeper (*Tecoma radicans* (L.) Juss.) a diffuse, indefinite, brown or olivaceous coating is formed. This shows on the upper surface as a slight chlorosis of the tissue.

Specimens collected: Bastrop, 2023; Victoria, 2519.

Leaf-spot (*Septoria tecomæ* Ell. and Ev.).—The diseased areas are purplish throughout in the earlier stages of their development, 2 to 3 mm. in diameter, and with an indefinite outline. Later a minute, central, grayish patch is formed in which the pycnidia are produced.

Specimen collected: Austin, 1317.

TULIP TREE.

Leaf-blight (*Gloeosporium liriodendri* Ell. and Ev.).—The leaves of the tulip tree (*Liriodendron tulipifera* L.) may show extended, dead, brown patches which involve part or the whole of the leaf lobes, advancing from the tips or margins. The spots are light brown and darker at the advancing edges. *Gloeosporium liriodendri* is present, but it is impossible to say whether it is the entire cause of the blight.

Specimens collected: New Braunfels, 1680; Seguin, 2281.

Leaf-spot.—The leaves of the tulip tree in one locality showed a definite spotting which indicates a fungous trouble, although no fungus spores were found. The spots are irregularly circular, 4 to 8 mm. in diameter, dark brown or black, surrounded by a broad zone of yellow which fades out without a definite boundary. On the lower surface the spots are less pronounced and more of a purplish-black color. The affected leaves may show only a few spots or as many as 25, and in some cases extensive, dead, brown areas may be produced.

Specimen collected: Georgetown, 2370.

UMBRELLA CHINA TREE.

Root-rot (*Ozonium omnivorum* Shear.).—This was found on an umbrella China tree (*Melia azedarach* L.) in a nursery where the root-rot had killed the young trees of black locust in an adjacent plat.

Specimen collected: Georgetown, 2352.

VIRGINIA CREEPER.

Leaf-spot (*Cercospora pustula* Cke.).—This fungus produces on the Virginia creeper (*Ptedera quinquefolia* (L.) Greene) dark-brown, purple, or almost black spots, subcircular or angular, 1 to 2 mm. in diameter or smaller, and generally surrounded by a zone of yellow. Colors are more dilute on the under surface.

The conidiophores are epiphyllous, fasciculate in rather sparse groups, continuous, 35 to 45 by 4 μ , uniformly yellowish brown; spores smoky, clavate, straight or curved, 28 to 72 by 4 μ , and two or three septate. (Pl. III, fig. 5.) Differs from *C. ampelopsidis* in having smaller spores, and epiphyllous conidiophores.

Specimens collected: Austin, 1277; New Braunfels, 1669.

Leaf-spot (*Phyllosticta ampelopsidis* Ell. and Martin).—Definite, circular, brown spots, 1 to 5 mm. in diameter, with a darker border, are characteristic of this trouble.

Specimens collected: Austin, 1547; New Braunfels, 1670.

WALNUT.

Leaf-spot (*Phleospora multimaculans* Heald and Wolf, 32).—The spots on the leaves of the walnut (*Juglans* sp.) produced by this fungus average about 1 mm. in diameter, are subcircular, dark brown with a darker border on the upper surface, and about a uniform brown on the under surface. The spots may be few in number, or they may be so numerous as almost completely to cover the leaf. It is very severe in some cases and causes much defoliation.

The pycnidia are hypophyllous, 30 by 45 μ ; the spores are generally curved, hyaline, nearly cylindrical, 20 to 40 by 3 to 3.5 μ , and one to three septate. (Pl. V, fig. 11.) The general symptomatology and the close relationship of the hosts indicate that this is the same species as described on the sycamore (p. 79), although there are slight morphological differences.

Specimens collected: (1) On *Juglans nigra* L.—Austin, 1538, 2426; Victoria, 2337; Stockdale, 2621; Gonzales, 2632; Flatonia, 2721 (type specimen); Falfurrias, 2460. (2) On *Juglans regia* L.—Austin, 366; Falfurrias, 2461.

WILD CHINA TREE.

Leaf-spot (*Cylindrosporium griseum* Heald and Wolf, 32).—Very numerous grayish or whitish, circular or slightly angular spots are produced on both surfaces of the leaflets and the rachis of the wild China tree (*Sapindus drummondii* Hook. and Arn.) The spots vary in size from 1 to 5 mm. with a predominating size of 1 to 2 mm. and show more prominent veins owing to the shrinking of the tissue. They may become confluent and cause extended dead areas (Pl. XIX, fig. 1).

The acervuli are amphigenous, more abundant on the upper surface, and are located immediately over the prominent veins (Pl. VI, fig. 12); they may be nearly circular in outline or much elongated along the veins, pale when young, becoming darker with age. The spores are cylindrical, slightly curved or sometimes straight, hyaline, 90 to 135 by 3 to 4.5 μ , and seven to nine septate (Pl. VI, fig. 11).

Specimens collected: Kerrville, 1588; Llano, 1757 (type specimen); Bastrop, 2026; San Marcos, 2098.

Powdery mildew (*Uncinula circinata* Cke. and Pk.).—The mycelium of the fungus forms a very effuse coating, most abundant on the lower surface. The leaves first become yellow and later dry and brown. The scattered perithecia are produced on the lower surface, dark brown in color, 150 to 180 μ in diameter, with clear appendages about equal in length to the diameter of the perithecium. The asci are elongated 65 to 70 by 25 to 30 μ , containing six to eight ascospores 15 to 18 by 9 to 12 μ . This species is somewhat doubt-

fully referred to *U. circinata*. Salmon records it for species of *Acer* only.

Specimens collected: Austin, 815, 441.

WILLOW.

Leaf-spot (*Cercospora salicina* Ell. and Ev.).—Dark-brown, irregular, more or less confluent areas from 3 to 8 mm. in diameter are present on the leaves of the willow (*Salix* sp.). The greater part of the leaf becomes involved.

Specimens collected: New Braunfels, 1724; Victoria, 2530; Falfurrias, 2462; Floresville, 2856.

Rust (*Melampsora bigelowii* Thm.).—The yellow sori appear on the foliage, upon the under surface of the leaves.

Specimens collected: Austin, 83, 237.

WISTARIA.

Leaf-spot (*Phyllosticta wistariae* Sacc.).—This fungus on the wistaria (*Kraunhia* sp.) causes circular grayish or brown spots 2 to 5 mm. in diameter, with a narrow purple border. Pycnidia are not abundant, and on some of the spots a species of *Alternaria* is present. Affected leaves showed considerable chlorosis.

Specimen collected: Austin, 1304.

DISEASES OF ORNAMENTAL PLANTS.

BALSAM-APPLE.

Leaf-blight (*Ramularia momordicae* Heald and Wolf, 32).—In the early stages of this disease the leaves of the balsam-apple (*Momordica balsamina* L.) show irregular blotches of yellow. As the disease advances, circular to subcircular yellowish-brown areas, varying from 1 to 10 mm. in diameter, with a more or less evident zonation, are formed on the upper side of the leaf. On the lower surface these areas become depressed with a ridged margin and are dark brown in color, due to the abundance of conidiophores and conidia. The conidiophores, aggregated in tufts of 8 to 14, are 30 to 45 by 4 to 5 μ in size and brown in color. The spores are cylindrical, hyaline, 42 to 65 by 4 to 5 μ , and 1 to 5 septate. (Pl. V, fig. 1.) The spots are often so numerous as to be confluent, causing the leaves to curl and become dry. Much defoliation results.

Specimen collected: Falfurrias, 2482 (type specimen).

BEGONIA.

Bacterial leaf-spot (*Bacillus pyrocyaneus* P. and D.) (?).—The first appearance of this trouble on the leaves of the begonia (*Begonia* sp.)

can be noted by the presence of purplish areas 1 to 2 mm. in diameter. These spots become depressed, often show concentric zonation, and increase in size to 4 to 8 mm., with a wide area of yellow, dead tissue around them. The yellow areas may fuse, thus involving a large part of the leaf, so that it is completely destroyed. (Pl. XVII, fig. 2.) This is probably the same disease that occurs in France, although it was not observed to attack the stems but only the leaves (40). The disease was observed in only a single locality, on greenhouse plants. No cultural work with the organism was attempted.

Specimens collected: San Antonio, 1411, 3176.

CANDYTUFT.

Dodder (*Cuscuta indecora* Choisy).—This parasite was observed on the candytuft (*Iberis* sp.) in only a single locality where it had spread to a considerable extent.

Specimen collected: San Antonio, 1372.

CANNA.

Leaf-blight.—A very serious leaf disease of the canna (*Canna indica* L.) appears at first as minute yellowish spots which become from 5 to 10 mm. in diameter, with brown centers. When isolated they are subcircular in outline, but when abundant they coalesce so that large irregular areas are involved. The brown parts show alternating concentric rings of lighter and darker areas of brown. Examination reveals no evidence of either fungi or bacteria, yet the trouble is apparently of fungous origin. In severe cases the entire leaf or leaf tip becomes dead and brown.

Specimens collected: New Braunfels, 1672, 1710.

CARNATION.

Root-rot (*Fusarium* sp.?).—This root disease was observed on the carnation (*Dianthus caryophyllus* L.) both in the greenhouse and in an irrigated garden. The smaller roots are destroyed and the larger ones become badly disintegrated.

Considerable loss results among young plants.

Specimens collected: San Antonio, 1335; Austin, 1914.

Rust (*Uromyces caryophyllinus* (Schrk.) Schrt.).—This fungus was collected in a greenhouse in a single locality. The brown sori were formed on the leaves and stems, but were not sufficiently abundant to cause serious harm.

Specimens collected: Austin, 2941, 3059.

CASTOR BEAN.

White leaf-spot (*Cercospora ricinella* Sacc. and Berl.).—On the foliage of the castor bean (*Ricinus communis* L.) this fungus causes the formation of small circular spots from 1 to 2 mm. in diameter. These spots are gray on both surfaces and have a well-defined, raised, purple margin. When the spots are abundant the leaves become yellow.

Specimens collected: Falfurrias, 2443; Flatonia, 2737; Hallettsville, 2790; Austin, 2921.

CENTURY PLANT.

Blight (*Stagonospora gigantea* Heald and Wolf, 32).—The disease begins on the tips or margin of the leaves of the century plant (*Agave americana* L.) and advances toward the base. (Pl. XVI, fig. 1.) The diseased tissue becomes dry, gray, and zonate, marking the periodic growth of the fungus. The pycnidia are on both leaf surfaces, covered at first, and at length protruding. They vary from 500 to 600 μ in diameter. (Pl. XVI, fig. 2.) The spores are large, hyaline, cylindrical, and slightly clavate, densely granular and frequently with many guttulæ, three septate and 72 to 115 by 13 to 15 μ . (Pl. V, fig. 3.) Our species differs from *S. macrospora* (Dur. and Mont.) Sacc., principally in having much larger spores, and also larger pycnidia.

This disease was very serious, blighting the plants in all the localities where it was observed.

Specimens collected: Austin, 1283 (type specimen); San Antonio, 1377; Boerne, 1648.

CHINA ASTER.

Stem-rot (*Fusarium* sp.?).—This fungus on the China aster (*Callistemma chinensis* (L.) Skeels) was the cause of a very considerable loss in the one locality in which it was observed. The young plants in the benches remain without any apparent growth for a time, then wither and die, with a serious disintegration of the stem near the ground.

Specimen collected: Austin, 1445.

CHRYSANTHEMUM.

Leaf-spot (*Septoria chrysanthemi* Allesch.).—This leaf-spot of chrysanthemum (*Chrysanthemum stipulaceum* (Moench) W. F. Wight) has been collected twice from greenhouses. In some cases it causes a considerable amount of defoliation, especially on the lower part of the plant.

Specimens collected: Austin, 380; Georgetown, 2368.

Root-knot (*Heterodera radiculicola* (Greef) Mül.).—Observed in only a single locality. Affected plants were much dwarfed.

Specimen collected: Austin, 1921.

COLUMBINE.

Leaf anthracnose (*Gloeosporium aquilegiae* Thm.).—Large marginal spots, usually irregular in outline, are formed on the leaves of the columbine (*Aquilegia* sp.). These diseased areas are yellowish brown in color with a brown border and often a yellowish zone toward the advancing edge of the affected tissue. The lower surface shows the same colors except that they are more dilute. On the upper surface are numerous little dots, the acervuli. Observed in greenhouses only.

Specimens collected: Beeville, 1866; Austin, 2864.

CYCAS.

Blight (*Ascochyta cycadina* Scalia).—The leaflets of *Cycas revoluta* Thunb. turn yellow at the tips, and as the trouble advances the older diseased portions become brown. The pycnidia, black and more or less scattered, form on the upper surface. Observed in a single locality where it was abundantly present and apparently the cause of considerable injury.

Specimen collected: Beeville, 1852.

DAISY.

Dodder (*Cuscuta indecora* Choisy).—This was observed on the daisy (*Chrysanthemum* sp.) in a garden at San Antonio.

Specimen collected: San Antonio, 1664.

Leaf-spot (*Cercospora chrysanthemi* Heald and Wolf, 32).—The diseased areas are raised above and sunken below, and vary in size from 2 to 10 mm. They have very definite elevated borders, are sub-circular or irregular in outline and brown in color, becoming grayish with age. The conidiophores, present on both surfaces, are densely fasciculate, brown, septate, 45 to 75 by 4 μ . The conidia are clavate, 40 to 120 by 4 μ , many septate, and dilutedly colored. (Pl. III, fig. 4.)

When the spots are abundant the leaf becomes brown between the diseased areas.

Specimen collected: San Antonio, 1659 (type specimen).

ELEPHANT'S-EAR.

Leaf-spot.—On the upper surface of the leaves of elephant's ear (*Colocasia esculenta* (L.) Schott.) the spots are circular in outline, 5 to 15 mm. in diameter, with a brown center and a surrounding zone

of yellow, shading out into the green tissue without a definite boundary. On the lower surface the spots are more definite in outline, with a brown center, surrounded by a yellowish-brown area with often a zone of diffuse white bordering the spot. This zone is 1 to 2 mm. wide, and probably marks the advance of the fungus. Only sterile fungous filaments were found. The affected leaves become chlorotic.

Specimen collected: New Braunfels, 1868.

FOUR-O'CLOCK.

White-rust (*Albugo platensis* (Speg.) Swingle).—This species of white-rust has been found on the common four-o'clock (*Mirabilis jalapa* L.). Sori were very abundant on the leaves which turned brown and shriveled, while those in which the disease was not so far advanced showed a marked chlorosis. Wilson (51) does not record this species for the four-o'clock, although it is common on other species of the Allioniaceæ.

Specimens collected: Austin, 3019, 3101.

GERANIUM.

Bacterial leaf-spot.—Geraniums (*Pelargonium* sp.) have been found to suffer in the greenhouse from what is apparently a bacterial spot. The affected leaves show numerous subcircular, brown or somewhat pellucid areas which are crowded full of bacteria. With the advance of the disease the intervening leaf tissue turns brown, and extensive dead, wrinkled areas result which show the original foci as darker spots scattered over the dead portions. Affected leaves generally show more or less chlorosis and may fall before they turn brown. (Pl. XVII, fig. 1.) Young plants in the same house were affected with a stem-rot which was probably also of bacterial origin.

Specimens collected: Austin, 374, 474, 1920.

HOLLYHOCK.

Leaf-spot (*Cercospora althaeina* Sacc.).—The numerous small circular or angular spots 1 to 5 mm. in diameter produced on the leaves of the hollyhock (*Althaea rosea* (L.) Cav.) by this fungus are reddish brown with a darker border and often a lighter center. The entire area is raised on the upper surface and depressed on the lower.

Specimen collected: Austin, 1904.

IRIS.

Leaf-blight (*Heterosporium gracile* (Wallr.) Sacc.).—This blight on the iris (*Iris* sp.) produces an abundance of spots which make their

appearance first on the distal portions of the leaves. The young spots show a yellow center surrounded by a zone of watery tissue. The older spots which have produced tufts of conidiophores are circular or elliptical, reaching 3 to 8 mm. in length, and show a gray center surrounded by a zone of brown, bordered by a narrow, watery area. The fungus is much more abundant toward the tips of the leaves and proceeds downward, the terminal portions of the leaves often becoming brown and dead, with the more or less zonate spots still conspicuous. In serious infections the leaf tissue turns yellow in advance of the fungus, and many leaves may be completely killed.

Specimens collected: On Peace variety—Austin, 457, 1323, 1436.

MAY-APPLE.

Rust (*Kuehneola hibisci* (Syd.) Arth.).—This rust on the May-apple (*Malva viscus drummondii* T. and G.) produces very abundant, almost punctiform sori upon the under surface of the leaves and causes more or less browning of the upper surface.

Specimen collected: Austin, 372.

MEXICAN BLUEBELL.

Leaf-mold (*Cercospora nepheloides* Ell. and Holw.).—Diffuse olive-green patches appear on the leaves of the Mexican bluebell (*Eustoma russellianum* (Hook.) Griesb.) At first these patches are more or less circular, gradually spreading over large portions of the leaf, with considerable chlorosis. In the advanced stages of the disease the conidiophores and conidia have become evenly distributed over the brown, dead tissue.

Conidiophores 30 to 42 by 3 to 4 μ , brown, in dense fascicles; conidia 30 to 60 by 3 to 4 μ , brown, clavate, several septate. (Pl. II, fig. 3.) Both leaf surfaces are equally attacked, the lower leaves being most affected.

Our specimens agree with *C. nepheloides* Ell. and Holw. on *E. silenifolium* Salisb. No published descriptions of this species have been found, and the determination was made by a comparison of our specimens with one issued by S. B. Parish under the above name, labeled "Santa Barbara, Cal., Sep. '94."

Specimen collected: Austin, 1556 (type specimen).

PERIWINKLE.

Dodder (*Cuscuta indecora* Choisy).—This parasite on periwinkle (*Vinca rosea* L.) had run rampant in a garden.

Specimen collected: San Antonio, 1863.

ROSE.

Cane canker (*Coniothyrium fuckelii* Sacc.).—On the rose (*Rosa* spp.) canes or stems brown, sunken patches, 1 to 4 or 5 cm. in length, are formed. The stem may be girdled as the filaments extend through the cortex. Sometimes the open cankers are not so evident, the fungus being more diffuse. The pycnidia are formed just beneath the epidermis, at length protruding.

Specimens collected: Austin, 1282; San Antonio, 1384.

Dodder (*Cuscuta indecora* Choisy).—This was present in a garden where it had grown on several other hosts.

Specimen collected: San Antonio, 1374.

Leaf-blotch (*Actinonema rosae* (Lib.) Fr.).—This fungus has been observed in gardens and nurseries and produces a considerable amount of defoliation, especially in the nurseries.

Specimens collected: Austin, 20, 379, 1278, 1919, 2939; Victoria, 2336; Stockdale, 2640; Falfurrias, 2463.

Leaf-spot (*Cercospora rosicola* Pass.).—The spots produced by this fungus are circular, 1 to 5 mm. in diameter, with a pronounced purple border and a brown or grayish center. More or less yellowing of the foliage and defoliation occur when the spots are abundant.

Specimens collected: Austin, 371, 381, 1442; Brenham, 1456; Seguin, 2328; Georgetown, 2373; Victoria, 2524; Gonzales, 2687.

Powdery mildew (*Sphaerotheca humuli* (DC.) Burr. and *S. pannosa* (Wallr.) Lev.).—The first of these is the greenhouse form and is not so common as the latter. Early in the summer roses are very commonly completely defoliated by the ravages of *S. pannosa*.

Specimens collected: (1) (*S. humuli*)—San Antonio, 1370. (2) (*S. pannosa*)—Austin, 1275, 2940.

Rust (*Phragmidium disciflorum* (Tode) James).—The æcial stage was so abundantly present that the leaves were very conspicuously chlorotic above, while the orange-colored æciospores covered the lower surface.

Specimens collected: Austin, 3119; San Antonio, 3181.

STANDING CYPRESS.

Powdery mildew (*Sphaerotheca humuli* (DC.) Burr.) (?).—This mildew was very abundant in one locality where standing cypress (*Gilia rubra* (L.) Heller) was cultivated in large beds. The lower leaves were attacked first and many were completely killed. No perfect fruits were found. The mildew showed an abundance of a species of *Cicinnobolus*.

Specimens collected: Austin, 1309, 1437.

SWEET ALYSSUM.

Dodder (*Cuscuta* sp.?).—Sweet alyssum (*Konia maritima* (L.) R. Br.) infested with dodder was found in one locality. Not flowering.

Specimen collected: San Antonio, 1372.

SWEET PEA.

Dodder (*Cuscuta indecora* Choisy).—This parasite was present on the sweet pea (*Lathyrus odoratus* L.) and also on several other kinds of plants growing near.

Specimen collected: San Antonio, 1375.

VIOLET.

Leaf-spot (*Alternaria violae* Gall. and Dorsett).—This disease occurs on the leaves of the violet (*Viola odorata* L.), commencing with small yellowish spots. The spots are somewhat circular, 1 to 5 mm. in diameter, and become yellowish white at maturity. They frequently spread so that large areas are involved.

Specimens collected: San Antonio, 1383, 1662, 3180; Uvalde, 1964.

Leaf-spot (*Cercospora violae* Sacc.).—Numerous small pale spots are formed on the leaves. They vary in size from 1 to 3 mm., and are margined by a zone of brown.

Specimens collected: Beeville, 1856; Austin, 1917; Lockhart, 2131; Seguin, 2329; Victoria, 2334, 2523; Georgetown, 2372; Cuero, 2577; Flatonia, 2739; San Antonio, 3178.

ZINNIA.

Leaf-spot (*Cercospora atricincta* Heald and Wolf, 32).—This disease on the leaves of the zinnia (*Crassina elegans* (Jacq.) Kuntze) is characterized by the presence of irregular, angular, gray spots with a brown border. When the spots are abundant this border is narrow and the spots are small, 1 to 2 mm. in diameter. When they are few they may be 4 mm. in diameter, with a broad marginal zone of purplish or dark brown. The conidiophores are found on both surfaces in small groups, brown in color, septate, 45 to 70 by 3.5 to 4.5 μ .

The conidia are dilute brown, many septate, clavate, 100 to 200 by 4 to 4.5 μ . (Pl. I, fig. 4.)

This is quite common in gardens.

Specimens collected: San Antonio, 1381, 1660; Victoria, 2506 (type specimen).

DISEASES OF WILD PLANTS.

ARROW LEAF.

Leaf-spot (*Cercospora sagittariae* Ell. and Kellerm.).—This disease on the arrow leaf (*Sagittaria* sp.) is characterized by the presence of grayish-brown, circular, or subcircular spots, 2 to 10 mm. in diameter, with a darker border and exhibiting more or less concentric zonation. In some cases adjacent foci become confluent, thus involving larger areas of the leaf. Some chlorosis is frequent in badly affected leaves.

Conidiophores on both surfaces, in clusters of 2 to 5, brown, straight, continuous or one septate, 6 by 60 μ ; spores straight or curved, tapering, club shaped, four to five septate, contents homogeneous or distinctly two guttulate, hyaline, or faintly smoky, 120 to 140 by 5.5 to 8 μ . (Pl. IV, fig. 1.)

Our specimens differ from *C. sagittariae* Ell. and Kellerm. in the size of the spores, which are recorded as 60 to 80 by 3 to 4 μ (15).

Specimens of *Sagittaria lancifolia* L. are affected with the same *Cercospora*, which is not perfectly developed, since the spores are 50 to 80 by 3.5 to 5 μ , indistinctly septate, more nearly straight, and hyaline. The general symptomatology is similar.

Specimens collected: (1) On *Sagittaria lancifolia* L.—Collins's Gardens, San Antonio, 1386 (represents young infections with immature spores). (2) On *S. platyphylla* (Engelman) Sm.—New Braunfels, 1676; San Antonio, 3164; San Marcos, 2121 (shows mostly immature spores and imperfectly developed spots). (3) On *Sagittaria* sp.?—Lockhart, 2064 (has but few mature spots).

BLUEBONNET.

Powdery mildew (*Erysiphe polygoni* DC.).—The stem, leaves, and pods of the bluebonnet (*Lupinus texensis* Hook.) are covered by the powdery white network of fungous filaments. Affected plants are paler green, with yellow-margined leaves, some of which are dry.

Specimen collected: Austin, 3126.

BLUET.

Rust (*Aecidium oldenlandianum* Ell. and Tracy).—The affected leaves of the bluet (*Houstonia angustifolia* Michx.) show considerable chlorosis. Nearly all leaves are attacked, so that affected plants are rendered conspicuous by their yellow color. The yellowish cluster cups containing the orange-colored aeciospores open to the lower surface of the leaves.

Specimens collected: Austin, 2947, 2951.

BOERHAVIA.

White-rust (*Albugo platensis* (Speg.) Swingle).—Blisterlike elevations, each of which contains a white, powdery mass of spores, are

formed on the upper surface of the leaf of the *Boerhavia* (*Boerhavia* spp.). This disease is very widely distributed, but apparently causes little injury.

Specimens collected: San Antonio, 1371, 3175; New Braunfels, 1697; Bastrop, 2033; Lockhart, 2075; Cotulla, 2135; Seguin, 2318; Victoria, 2527; Nursery, 2574; Cuero, 2590; Stockdale, 2608; Gonzales, 2686; Kennedy, 2832.

BROOMWEED.

Rust (*Aecidium chrysopsidis* Ell. and Anders.).—On the stems and leaves (much more abundantly on the stems) of the broomweed (*Gutierrezia texana* (DC.) Torr. and Gray) are whitish or yellowish pustules, the cluster cups. They form in such numbers on the main stems and branches that these parts become brown and are killed.

This rust has been described (13) as occurring on *Gutierrezia euthamia* Torr. and Gray and is probably the same as the one on this species, although no note of the fact has been found.

Specimens collected: Victoria, 2538; Gonzales, 2679.

BULL NETTLE.

Leaf-spot (*Septoria jatrophae* Heald and Wolf, 32).—This causes the formation of very characteristic, brown, circular areas on the leaves of the bull nettle (*Jatropha stimulosa* Michx.). These spots vary in size from 1 to 5 mm. and are frequently somewhat irregular in outline. At first they are dark brown with a darker, almost black, border. Later the centers become tan and sometimes gray, but always with a definite dark margin. The pycnidia are 120 to 150 μ , brown and immersed wholly in the leaf tissues. The spores are rod shaped or slightly clavate, hyaline, 40 to 50 by 3 μ and few septate.

The spots frequently are so abundant that they fuse, causing the drying of large portions of the leaf.

Specimen collected: Austin, 2429 (type specimen).

CAROLINA CLOVER.

Rust (*Uromyces elegans* B. and C.).—The minute brown sori appear abundantly on the lower surface of the leaflets of Carolina clover (*Trifolium carolinianum* Michx.).

Specimen collected: Austin, 3060.

COCKLEBUR.

Leaf-spot (*Cercospora xanthicola* Heald and Wolf, 32).—This fungus produces upon the leaves of the cocklebur (*Xanthium* spp.) numerous circular or subcircular spots, 0.5 to 2 mm. (1 mm. average size) in diameter, with dirty-gray or brownish centers surrounded by a nar-

row darker border. The number of infections on a single leaf may reach as high as 400 to 600, in which case the leaf shows more or less chlorosis, but frequently the spots are less numerous and the leaf shows little or no deviation from the normal color.

Conidiophores amphigenous, fascicles of 3 to 8, hyaline tipped, irregular-nodose for two-thirds the length, continuous or rarely septate, 3 to 3.5 by 60 to 100 μ . Spores 105 to 135 by 3 μ and reaching the length of 245 μ in some cases, very slender club shaped, tapering gradually from the base, generally somewhat curved, hyaline, and obscurely septate except in the basal portion. (Pl. II, fig. 4.)

Specimens collected: Luling, 2236; Georgetown, 2383 (type specimen); Nursery, 2567; Cuero, 2588; Gonzales, 2705; Yoakum, 2755; Hallettsville, 2790; Kennedy, 2836; Austin, 2871.

Rust (*Puccinia xanthi* S.).—The rust of the cocklebur is very common, producing numerous circular or slightly irregular spots on the leaves (minute to 1 cm. in diameter), pale yellow and sunken on the upper surface, dark brown with narrow yellow border on the under surface, and somewhat hypertrophied. Old spots frequently show gray centers on the under surface.

Specimens collected: Austin, 1413, 1545; Beeville, 1800; Lockhart, 2065; San Marcos, 2088; Hondo, 2251; Luling, 2241; Seguin, 2302; Georgetown, 2381; Victoria, 2343; Gonzales, 2664; Kennedy, 2822; Floresville, 2849.

CONVOLVULUS.

White-rust (*Albugo ipomoeae-panduranae* (S.) Swingle).—The white, blisterlike spots on the convolvulus (*Convolvulus hermanoides* Gray) were present on all parts of the plant. This disease is not recorded (51) as occurring on this species.

Specimens collected: Austin, 311, 814, 1265.

CORAL BEAD.

Leaf-spot (*Cercospora menispermii* Ell. and Holw.).—On the foliage of this climbing vine (*Cebatha carolina* (L.) Britton) very abundant dark-brown spots are present, 2 to 5 mm. in diameter. The margin of the spot pales out from a raised border which is almost black. With age the centers of the diseased areas become grayish. The spores are generally clavate, sometimes cylindrical, from 30 to 60 by 5 to 6 μ , brown, three to five septate.

No defoliation results.

Specimens collected: Sabinal, 1987; Bastrop, 2036; San Marcos, 2089; Luling, 2230; Seguin, 2313; Round Rock, 2409; Gonzales, 2681; Floresville, 2346.

CRANE'S-BILL.

Downy mildew (*Rhysotheca geranii* (Pk.) Wilson).—Very conspicuous, definite, downy, white areas are formed on the lower sur-

face of the leaves of the crane's-bill (*Geranium carolinianum* L.). They may be small and isolated or may involve the entire surface. In the earlier stages the upper surface of the foliage becomes yellow, but finally the entire leaf becomes dead and dry.

Specimen collected: Austin, 2988.

CROTON.

Dodder (*Cuscuta indecora* Choisy).—This was very abundant on the plants of croton (*Croton* spp.) in a single locality.

Specimen collected: San Antonio, 1373.

Rust (*Bubakia crotonis* (Cke.) Arth.).—In this species of rust the sori are very abundant. In the majority of specimens collected the uredinia are more abundant than the telia. In some the telia are much more abundant than the uredinia, and occur on both surfaces of the leaves and on the petioles and stems. The telia on the leaves are black, swollen cushions, still covered by the epidermis, 0.5 to 1 mm. in diameter and very abundant, causing the edges of the leaf blade to roll upward and inward. The telia on the stems may be similar in size to those on the leaf surfaces, but they are generally much larger and may form elongated cushions 3 to 10 mm. in length, which are confined to one side of the stem or completely encircle it. When uredinia only are present the leaves may also be curled and rolled, and the sori are frequently surrounded by a narrow zone of yellow. Our collections represent various other species of *Croton* in addition to *C. texensis* (Kl.) Muell. Arg.

Specimens collected: Luling, 2258; Georgetown, 2380; Round Rock, 2418; Falfurrias, 2442, 2489; Victoria, 2526; Cuero, 2582; Stockdale, 2647; Flatonia, 2736; Yoakum, 2757; Skidmore, 2817; Austin, 2907. All except 2907 represent uredinia only.

CROWNBEARD.

Leaf-spot (*Cercospora fulvella* Heald and Wolf, 32).—This disease on the crownbeard (*Verbesina texana* Buckl.) is characterized by the presence of irregular, yellowish-brown areas, 5 to 10 mm. in diameter, which sometimes become confluent, causing the death of larger areas. The color is more dilute and the spots less definite on the under surface. The conidiophores are epiphyllous or sometimes amphigenous, fasciculate, brown, septate, 45 to 150 by 4 to 5 μ ; spores clavate, straight, dilutedly colored, 40 to 60 by 4 to 5 μ , three to four septate. (Pl. III, fig. 7.)

Specimen collected: Austin, 406 (type specimen).

Leaf-spot (*Phyllosticta verbesinae* Heald and Wolf, 32).—This fungus produces numerous gray or whitish subcircular spots, 1 to 3 mm. in diameter and surrounded by an indefinite darker zone which

fades out into the green. The pycnidia are numerous, epiphyllous, 36 to 45 μ in diameter; the spores are oval or elliptical, 4 to 6 by 2.5 to 3 μ .

Specimen collected: Seguin, 2310 (type specimen).

Rust (*Puccinia cognata* Syd.).—Punctiform telia and uredinia are produced upon the under surface of the leaves. Common.

Specimens collected: Austin, 178, 346, 361.

DAYFLOWER.

Rust (*Uromyces spegazzinii* (De T.) Kern. nov. comb.).—Observed in only one locality, where it was very abundant on the dayflower (*Commelina virginica* L.).

Specimen collected: Austin, 232.

DOCK.

Dodder (*Cuscuta indecora* Choisy).—Observed on dock (*Rumex berlandieri* Meisn.) in a low, moist field, where it had grown over other plants.

Specimen collected: San Antonio, 1776.

EVENING PRIMROSE.

Powdery mildew (*Erysiphe polygoni* DC.).—Found on the evening primrose (*Oenothera laciniata* Hill) in only a single locality.

Specimen collected: Austin, 1051.

EUPHORBIA.

Rust (*Uromyces euphorbiae* Cke. and Pk.).—The rust is very common on the euphorbias (*Euphorbia* spp.) of this section, forming on the leaves very abundant brown, circular pustules.

Specimens collected: San Antonio, 1397, 3174; Austin, 1420, 1908, 3102; Lockhart, 2077.

FALSE DANDELION.

Rust (*Puccinia pyrrhopappi* Syd.).—The sori are produced profusely on the stems, leaves, and involucre of the false dandelion (*Sitilias multicaulis* (DC.) Greene). This rust was observed to be exceedingly abundant in and about Austin, where it caused the death of the plants.

Specimens collected: Austin, 1073, 1264, 2948, 3061; Hempstead, 1515.

FIREWEED.

Leaf-spot (*Cercospora vernoniae* Ell. and Kellerm.).—This fungus on the fireweed (*Vernonia* spp.) produces irregular, rounded, or angu-

lar spots, 2 to 5 mm. in diameter, brown or grayish in color, with a slightly darker border, frequently surrounded by a zone of yellow. Sometimes the spots become confluent, causing the death of the leaves.

Specimens collected: Austin, 1558; Seguin, 2324; Georgetown, 2378.

Rust (*Coleosporium vernoniae* B. and C.).—Minute yellow pustules are very abundant on the lower surface of the leaves and cause a yellow, punctate appearance of the upper surface.

Specimen collected: Austin, 345.

FLEABANE.

Leaf-spot (*Septoria erigeronetea* Pk.).—This disease on the fleabane (*Erigeron canadensis* L.) appears as distinct spots, 1 to 2 mm. in diameter, with a grayish center and brown border on the leaves, most abundantly on the lowermost. The black pycnidia show very plainly in the grayish center. The spores are 24 to 78 μ in length, which is in excess of the original description (39).

Specimen collected: Austin, 3033.

GAURA.

Rust (*Uromyces gaurinus* (Pk.) Long.).—The cluster cups on gaura (*Gaura coccinea* Pursh.) appear on both surfaces of the leaves and are so numerous that the leaves are destroyed.

Specimens collected: Austin, 2945, 3000.

GIANT RAGWEED.

Dodder (*Cuscuta indecora* (?) Choisy).—Found in only a single locality, where it was growing abundantly on the giant ragweed (*Ambrosia trifida* L.), as well as several other hosts.

Specimen collected: San Antonio, 1777.

Powdery mildew (*Erysiphe cichoracearum* DC.).—The collections of this fungus include only conidiospore specimens.

Specimens collected: San Marcos, 949; San Antonio, 3155.

Rust (*Puccinia xanthi* S. var. *ambrosiae* B. and Rav.).—This variety is quite similar to the rust on the cocklebur, but the sori are more abundant and generally smaller.

Specimen collected: Austin, 1415.

GOLDENROD.

Leaf-spot (*Cercospora reticulata* Pk.).—Numerous brown spots with indefinite margins appear on the leaves of the goldenrod (*Solidago* spp.). The spots are often confluent and the leaf tips may become brown, the tissue adjacent to the areas being killed.

Specimen collected: Elgin, 2007.

GROUND-CHERRY.

Leaf-spot (*Cercospora physalicola* Ell. and Barthol.).—This fungus on the ground-cherry (*Physalis* sp.) produces circular brown spots 3 to 10 mm. in diameter, which show a marked concentric zonation. It was found on only the lower leaves which were more or less shaded.

Conidiophores amphigenous, few in each cluster, 130 to 150 by 5 μ , several septate. Spores 60 to 130 μ or reaching 188 by 4 to 5 μ , five to many septate, nearly hyaline. (Pl. IV, fig. 5.)

Our specimens differ from the type in having longer conidiophores, amphigenous instead of epiphyllous, septate instead of continuous, and larger, more numerous septate spores.

Specimen collected: New Braunfels, 1715.

HORSE NETTLE.

Leaf-spot (*Cercospora atro-marginalis* Atk.).—This disease appears on the leaves of the horse nettle (*Solanum carolinense* L.) as circular or somewhat angular dark-brown spots from 3 to 5 mm. in diameter. These spots frequently are concentrically zonate, with a dark margin. The conidiophores are densely fascicled and show as brown heaps when aggregated.

Specimen collected: Gonzales, 2867.

HYDROCOTYLE.

Leaf-spot (*Cercospora hydrocotyles* Ell. and Ev.).—Very numerous reddish-brown spots are produced on the leaves of hydrocotyle (*Hydrocotyle* spp.). They are circular or slightly angular, and 1 to 3 mm., mostly 2 mm., in diameter. The leaf tissue between the spots is at first yellow, turning brown, with the fungous foci darker. The conidia vary from 30 to 80 by 3 to 3.5 μ , exceeding the size given in the original description (16), which measurement is 30 to 40 by 3 μ .

Specimens collected: On *H. umbellata* L.—Von Ormy, 1117; San Antonio, 3165. On *H. verticillata* Nutt.—Georgetown, 2384.

Rust (*Puccinia hydrocotyles* (Lk.) Cke.).—The rust appears on the leaves of *H. umbellata* as minute circular brown pustules, often so closely clustered as to give the leaves a brown color and cause their death.

Specimen collected: On *H. umbellata* L.—Von Ormy, 1117.

INDIAN MALLOW.

Rust (*Puccinia heterospora* B. and C.).—This rust on the Indian mallow (*Abutilon texense* T. and G.) produces circular telia 0.5 to 3

mm. in diameter on the lower surface and punctiform telia above. Old or mature telia generally show a gray center.

Specimens collected: Austin, 24, 1421, 2884, 3113; San Antonio, 3160.

INDIGO PLANT.

Dodder (*Cuscuta* sp.).—The dodder was observed on the indigo plant (*Indigofera leptosepala* Nutt.) in only a single locality.

Specimen collected: Boerne, 1639.

KNOTWEED.

Leaf-spot (*Cercospora polygonacea* Ell. and Ev.).—This disease on the knotweed (*Polygonum* spp.) appears as suborbicular spots, 2 to 3 mm. in diameter, reddish brown above with a darker, raised margin and a dark zone of tissue beyond the elevated border. Areas become brown below and adjacent tissue becomes yellow.

Specimen collected: Cuero, 2586.

Powdery mildew (*Erysiphe polygoni* DC.).—Both leaf surfaces have a white, felty covering, due to the interlacing mycelium and the summer spores.

Specimens collected: San Marcos, 943; San Antonio, 1363, 3173; Austin, 3116.

Rust (*Puccinia polygoni-amphibii* P.).—The minute reddish-brown sori open to the under surface. Frequently they cause chlorosis and death of the leaves.

Specimen collected: San Marcos, 942.

MALLOW.

Leaf-spot (*Cercospora malachrae* Heald and Wolf, 32).—Circular or subcircular spots are produced upon the leaves of the mallow (*Malachra capitata* L.). They are 1 to 4 mm. in diameter, with yellowish-gray centers on which the conidial tufts are evident, surrounded by a dark-purple border. The spots are slightly less pronounced upon the under surface.

The conidiophores are amphigenous, in fascicles of few to a dozen, brown with slightly paler tips, nodose extremities, 90 to 120 by 4 to 5 μ , and several septate; conidia clavate, hyaline, slender pointed, 100 to 210 by 4 to 5 μ , many septate. (Pl. IV, fig. 3.) This species of *Cercospora* seems to be distinct from the many described for different species of the Mallow family. It agrees most nearly with *C. polymorpha* Bubák.

Specimen collected: Victoria, 2847 (type specimen).

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MINT.

Powdery mildew (*Erysiphe galeopsidis* DC.).—Only the conidial stage of this mildew was observed on mint (*Stachys drummondii* Benth.).

Specimen collected: San Marcos, 947.

MORNING-GLORY.

Leaf-spot (*Phyllosticta ipomoeae* Ell. and Kellerm.).—The leaves of the morning-glory (*Ipomoea* spp.) develop conspicuous brown spots with a narrow dark margin. They are suborbicular and about 4 mm. in diameter, becoming grayish with age. A few black pycnidia are embedded in these areas.

Specimens collected: Austin, 378; Seguin, 2316; Victoria, 2507.

Rust (*Puccinia cassipae* B. and C.).—Both the cluster cups and teleutospores are abundantly present, often on the same leaves or stems.

Specimens collected: Austin, 192, 198, 330; San Marcos, 2105; Victoria, 2345, 2346; Flatonia, 2724.

White-rust (*Albugo ipomoeae-panduranae* (S.) Swingle).—White, blisterlike elevations are formed on the leaves and stems. When sufficiently abundant the foliage is apparently uniformly white. (Pl. XVIII, fig. 1.)

This trouble is very generally distributed. The wild morning-glories are common weeds in the cultivated fields and are affected by the same white rust which attacks sweet potatoes.

Specimens collected: Austin, 120, 420, 1305, 1306; New Braunfels, 1671; Sabinal, 1979; Lockhart, 2071; Seguin, 2296; San Marcos, 2093; Georgetown, 2369; Round Rock, 2415; Elgin, 1879; Flatonia, 2725; Stockdale, 2623; Gonzales, 2693; San Antonio, 3167.

MUSTARD.

White-rust (*Albugo candida* (P.) Rouss.).—The characteristic white, blisterlike heaps of conidia occur on both surfaces of the leaves of mustard (*Brassica nigra* (L.) Koch.), causing them to become yellow and dry.

Specimen collected: Austin, 3072.

NYMPHAEA.

Leaf-spot (*Phyllosticta orontii* Ell. and Martin).—The diseased areas on *Nymphaea advena* Soland are straw colored and several centimeters in length, generally elongated in the direction of the

veins, and concentrically zonate. The lines marking the zones are slightly elevated and darker.

Specimens collected: Georgetown, 2385; Von Ormy, 1162.

PARTHENIUM.

Rust (*Puccinia xanthi* S. var. *ambrosiae* B. and Rav.).—The sori, produced on the lower surface of parthenium (*Parthenium hysterophorus* L.), are characteristically brown and aggregated in circular patches. The spots show a yellowish-brown coloration on the upper surface.

Specimen collected: Kennedy, 2838.

PEPPERGRASS.

Downy mildew (*Peronospora parasitica* (P.) De By.).—This fungus on the peppergrass (*Lepidium virginicum* L.) causes the under surface of the leaves to appear downy white in small spots or extended areas, while the upper surface of the diseased spots is pale yellow.

Specimen collected: Austin, 2952.

PIGWEED.

Leaf-spot (*Cercospora brachiata* Ell. and Ev.).—The spots on the pigweed (*Amaranthus* spp.) are first dark brown, becoming grayish brown, subcircular or irregularly rounded, 3 to 5 mm. in diameter. They become very abundant, causing the leaves to curl and dry.

Specimen collected: On *A. spinosus* L.—Kennedy, 2327.

White-rust (*Albugo bliti* (Biv.) Kuntze).—The formation of the white pustules on the under surface of the leaves marks the presence of this fungus.

Specimens collected: (1) On *A. albus* L.—Austin, 376. (2) On *A. retroflexus* L.—Austin, 1815; San Marcos, 2092; Uvalde, 1935; Luling, 2229; Victoria, 2516; Stockdale, 2635; San Antonio, 3179. (3) On *A. spinosus* L.—Llano, 1760; Lockhart, 2059; Falfurrias, 2448.

POKEWEED.

Leaf-spot (*Cercospora flagellaris* Ell. and Martin).—Circular or slightly irregular brown spots 2 to 5 mm. in diameter appear on the foliage of the pokeweed (*Phytolacca americana* L.). The spots have a dark-brown, elevated border and they become grayish when older. Frequently they are abundantly formed on the leaf tips, resulting in the drying of the affected portions. In some localities affected plants were completely defoliated and dead.

Specimens collected: Austin, 336; Brenham, 1458; New Braunfels, 1722; Elgin, 1885; Bastrop, 2025; San Marcos, 2115; Cuero, 2803; Stockdale, 2622; Gonzales, 2696; Flatonia, 2744; Yoakum, 2769.

PRICKLY PEAR.

Anthrachnose (*Gloeosporium* sp.).—The prickly pears (*Opuntia* spp.) of this region are frequently attacked by this fungus, which produces generally circular or subcircular depressed areas, with grayish centers densely covered with minute black acervuli which become less abundant toward the periphery, which is limited by a zone of brown. The spots are most commonly 1.5 to 2.5 cm. in diameter, but they may be much larger in some cases. The isolated spots may coalesce and cause the complete death of a stem segment. The diseased area always extends completely through the stem segment, and the old dead tissue may persist or it may fall out. In all cases of spots of the average size mentioned the advance of the fungus is limited by a development of corky tissue at the periphery of the area. This same fungus produces on young fronds, under favorable conditions of temperature and moisture, a severe rotting, and the fungus may advance through an entire segment in a few days, starting from a single center of infection, and thus leave the segment brown and completely dead. In this stage an abundance of pale acervuli is generally produced at the center of the infected area. In such cases the frond is chlorotic some distance beyond the advance of the fungus, and there is frequently a marked gummy exudation from the spot.

Specimens collected: Austin, 562; Llano, 1773; Hondo, 2252; Georgetown, 2393; Round Rock, 2406.

Black-spot (*Perisporium wrightii* B. and C.).—This fungus produces superficial black spots, generally circular in outline and 5 mm. to 1 cm. in diameter, on the stem segments. They may be few in number, or they may be sufficiently abundant to coalesce and nearly cover the surface. The black color is due to the large numbers of spore fruits or perithecia. No instances have been observed where the fungus was causing any material injury.

Specimens collected: Austin, 1293; Elgin, 1875; Round Rock, 2408.

Scald (*Hendersonia* (?) *opuntiae* Ell. and Ev.).—Probably the most general and the most severe disease of the prickly pear is what is popularly called "sun scald" in this territory. The whole surface of the older fronds becomes covered with a yellowish-brown, scaly growth of a corky character. In this scaly growth may be seen numerous minute black specks, the fruits of the fungus. Large plants may be killed, but the fungus remains superficial and the injurious effect is apparently due to the corky covering which cuts off the light in part and prevents the aeration of the underlying tissue. The network of dark-brown fungous filaments may be found just beneath the epidermal layer and also to some extent deeper down and inclosed in the corky layers.

The pycnidia are produced at the openings of the stomatal chimneys, and an aggregate of hyphæ generally closes the opening. The spores are pale brown, straight or slightly curved, two to three septate, and 25 to 30 by 3 μ .

A species of *Rhabdospora* may sometimes be associated with the trouble, but it is apparently of secondary importance.

Specimens collected: Austin; Falfurrias, 2467; Round Rock, 2407.

PURSLANE.

White-rust (*Albugo portulacae* (DC.) Kuntze).—This species of white-rust has been found on two different species of *Portulaca*.

Specimens collected: (1) On *Portulaca oleracea* L.—Beeville, 1811; Bastrop, 2028; Luling, 2248; Cuero, 2585; Stockdale, 2632. (2) On *Portulaca lanceolata* Eng.—Falfurrias, 2439.

RAIN LILY.

Rust (*Puccinia cooperiae* Long).—On the leaves of the small rain lily (*Cooperia drummondii* Herb.) are formed oval or elliptical brown sori, often very abundantly aggregated.

Specimen collected: Austin, 493.

RIVINA.

Leaf-spot (*Cercospora flagellaris* Ell. and Martin).—The general symptomatology of this disease on *Rivina laevis* L. is the same as the leaf-spot of the pokeweed (p. 99). Since it also agrees in size of conidiophores and conidia, it is very probably the same fungus, the hosts being related.

Specimens collected: Austin, 303, 1419.

RUELLIA.

Rust (*Puccinia ruelliae* (B. and Br.) Lagerh.).—On *Ruellia tuberosa* L. an abundance of sori are produced, punctiform to 1 mm. in diameter, mostly upon the upper surface of the leaves.

Specimens collected: Austin, 34, 412, 439; Beeville, 1797.

SAGE.

Rust (*Puccinia farinacea* Long).—Minute, rounded, brown sori are formed on the upper surface of the leaves of sage (*Salvia farinacea* L.).

Specimen collected: Austin, 349.

SENNA.

Leaf-spot (*Ramularia cassiaecola* Heald and Wolf. Syn.—*Cercospora occidentalis* Ell. and Kellerm.).—This fungus on senna (*Cassia*

sp.) first forms diffuse brown spots, circular, indefinitely margined, 1 to 5 mm. in diameter, and frequently bordered by a zone of yellow.

In severe infections the entire leaflet may turn yellow, with the exception of the brown spots on which the fungus is located.

The conidiophores are amphigenous, but more abundant on the under surface, closely fasciculate, brown, continuous except in the aggregated basal portion, and 24 to 30 by 3 to 4.5 μ ; the spores are 45 to 150 by 3 to 5 μ , olivaceous, nearly cylindrical, 1 to 5 septate, and when mature frequently guttulate. (Pl. V, fig. 2.)

An examination of Ravenel's specimens of *Cercospora occidentalis* and also of Ellis's collections of this species shows that they should have been referred to the genus *Ramularia*. Since there is already a valid *R. occidentalis*, the specific name can not be retained.

Specimens collected: On *Cassia occidentalis* L.—Beeville, 1868; Cuero, 2580; Stockdale, 2611; Yoakum, 2750; Hallettsville, 2773.

Rust (*Ravenelia longiana* Syd.).—The sori are formed on the lower surface of the leaves.

Specimen collected: On *Cassia roemeriana* Scheele—Llano, 1751.

SMILAX.

Leaf-spot (*Cercospora smilacina* Sacc.).—This is the most common leaf disease of the smilax (*Smilax bona-nox* L.). The foliage becomes thickly spotted with subcircular, reddish areas, with brown margins.

Specimens collected: New Braunfels, 1702; Llano, 1748; Elgin, 1876; Uvalde, 1929; Bastrop, 2037; Lockhart, 2063; Cotulla, 2179; Luling, 2226; Seguin, 2305; Georgetown, 2398; Round Rock, 2416; Gonzales, 2704; Flatonia, 2743; Yoakum, 2762; Hallettsville, 2792.

Leaf-spot (*Phyllosticta smilacis* Ell. and Ev.).—The diseased areas are conspicuously reddish brown or brown, circular or subcircular, and vary from 2 to 8 mm. in diameter. They have a very pronounced dark-brown border. The black, immersed pycnidia, 150 μ in diameter, are either scattered or peripheral and on both surfaces. Generally, however, they are on only one surface of a given spot. The spores are nearly spherical or slightly elongated, clear, granular, 10 to 14 by 7 to 9 μ . The spores in our specimens are smaller than in the type (15 to 20 by 7 to 9 μ).

Specimens collected: Austin, 360; Boerne, 1656; Round Rock, 2412, 2413; Hallettsville, 2789.

Rust (*Puccinia smilacis* S.).—The upper surface of the leaf is densely spotted with yellowish or brown circular spots from 1 to 2 mm. in diameter. On the under surface small brown sori have broken through the epidermis.

Specimens collected: Austin, 23; San Marcos, 2090.

SUNFLOWER.

Leaf-spot (*Cercospora pachypus* Ell. and Kellerm.).—Irregular, angular spots, 1 to 5 mm. in diameter, becoming dark brown, are formed on the foliage of the sunflower (*Helianthus* spp.). These areas fuse and, accompanied by more or less chlorosis, the leaves are killed.

Specimen collected: Hondo, 1939.

Powdery mildew (*Erysiphe cichoracearum* DC.).—Upon the upper side of the leaves appear conspicuous white patches, often covering the greater part of the leaf surface. Only the conidial stage was observed.

Specimen collected: San Antonio, 3159.

Rust (*Puccinia helianthi* S.).—The rust sori are formed in abundance on both wild and cultivated forms, frequently so as to render the under surface quite brown.

Specimens collected: San Antonio, 1357, 1388, 1392, 1780, 3162; Seguin, 2300; Cuero, 2576; Flatonia, 2718.

TICK TREFOIL.

Rust (*Uromyces hedysari-paniculati* (S.) Farl.).—The yellowish-brown sori on tick trefoil (*Meibomia* sp.) are very numerous on the lower surface of the leaves and sparse on the upper surface.

Specimen collected: Austin, 343.

TROMPILLO.

Dodder (*Cuscuta* sp. ?).—This parasite on the trompillo (*Solanum elaeagnifolium* Cav.) was not flowering, and consequently could not be identified.

Specimen collected: Bastrop, 2029.

Nematode leaf-curl (*Tylenchus* sp.).—This is quite common, causing the leaves to be curled and much hypertrophied. (Pl. XVIII, fig. 3.)

Specimens collected: Austin, 1262; Kennedy, 2833.

VINCETOXICUM.

Leaf-mold (*Cercospora bellynckii* (Westd.) Sacc.).—An olivaceous, brown, diffuse coating is formed on the leaves of vincetoxicum (*Vincetoxicum* spp.). The description (46) of the fungus states that it occurs on the lower leaf surface, but our specimen shows conidiophores on both surfaces. In other characters the agreement is satisfactory.

Specimen collected: Austin, 312.

Rust (*Puccinia gonolobi* Rav. and B.).—The sori are present on both stems and leaves. On the stems they are so numerous as to form a black crust. On the leaves they are scattered and on the lower surface.

Specimens collected: Austin, 334, 335, 1449.

VIRGIN'S-BOWER.

Leaf-blight (*Phleospora adusta* Heald and Wolf, 32).—This trouble on the virgin's-bower (*Clematis drummondii* T. and G.) is very general and very severe. The foliage has large, irregular, brown areas, generally beginning on the leaf tips. The entire leaves become dry and brown and more or less curled in the advanced stages of the disease.

The pycnidia are hypophyllous, 30 to 45 μ in diameter and sparse. The spores are cylindrical, hyaline, 18 to 36 by 3 to 3.5 μ , and one to three septate. (Pl. V, fig. 10.)

Specimens collected: New Braunfels, 1699; Austin, 1726 (type specimen); Llano, 1784; Beeville, 1833; Sabinal, 1976; Hondo, 1998; Bastrop, 2021; Seguin, 2303; Georgetown, 2390; Gonzales, 2654; Kennedy, 2825.

Rust (*Puccinia tomipara* Trel.).—Groups of yellowish-white cluster cups appear on the foliage in the spring and late fall. The telia and uredinia are reported as occurring on *Bromus* spp., but no collections have been made in our territory.

Specimens collected: Austin, 309, 438, 1424.

WATER CRESS.

Leaf-blight (*Cercospora nasturtii* Pass.).—The leaves of water cress (*Radicula nasturtium-aquaticum* (L.) Britten and Rendle) infested with this fungus show circular to subcircular straw-colored or dirty-yellow spots varying in size from 1 to 5 mm. There is generally more or less concentric zonation. The diseased plants are stunted and show a purple coloration of the foliage.

The conidiophores are continuous, 45 to 60 by 3.5 μ , and clear-tipped. The conidia are 65 to 115 by 3.5 μ , several septate, hyaline, and granular. (Pl. II, fig. 1.)

Specimen collected: Austin, 1448.

WATER WILLOW.

Leaf-spot (*Cercospora diantherae* Ell. and Kellerm.).—The affected leaves of water willow (*Dianthera americana* L.) show numerous gray or brown spots, 1 to 4 mm. in diameter, surrounded by a darker border. Extended areas of the leaf tissue may be killed and the

spots show as lighter areas in a dark ground. In the earlier stages of the disease a considerable degree of chlorosis may be exhibited.

Specimens collected: Austin, 64, 2870.

WILD GOURD.

Leaf-spot (*Cercospora cucurbitae* Ell. and Ev.).—Dirty-yellow, sub-circular or angular spots, 2 to 7 mm. in diameter, are produced on the wild gourd (*Cucurbita foetidissima* H. B. K.) by this fungus. The spores are 57 to 173 μ in length. This range of size is different from that given in the original description (48) (100 to 120 μ).

Specimens collected: New Braunfels, 1717; Llano, 1754; Elgin, 1877; Lockhart, 2086; Austin, 359, 1923; Sabinal, 1984; Luling, 2269; Seguin, 2289; Floresville, 2845; San Antonio, 3161.

WILD TOBACCO.

Leaf-spot (*Cercospora nicotianae* Ell. and Ev.).—This fungus on the leaves of wild tobacco (*Nicotiana repanda* Willd.) forms sub-circular areas 5 to 10 mm. in diameter. Because of the production of conidiophores and conidia on both surfaces, the center of the affected areas is brown with a lighter border.

Specimen collected: Austin, 3084.

WIND FLOWER.

Rust (*Transschelia cohaesa* (Long) Arth.).—The densely aggregated cluster cups, yellowish or dilutedly brown, appear on the lower surface of the foliage of the wind flower (*Anemone caroliniana* Walt.). The margins of the cups show quite commonly four recurved rays. This rust is very common and very abundant during March.

Specimens collected: Austin, 2935, 2944.

Smut (*Urocystis anemones* (P.) Wint.).—The brownish-black pustules are formed on the stems, petioles, and leaf blades. These pustules are covered at first and vary in size from very small to 2.5 or 5 cm. in length when on the stems.

Specimen collected: Austin, 2942.

WOOD SORREL.

Smut (*Ustilago oxalidis* Ell. and Tracy).—The seeds of the wood sorrel (*Oxalis stricta* L.) are replaced by a mass of brown spores, and when the capsule dehiscs these spores are forcibly ejected in clouds.

Specimens collected: Austin, 1261, 1263.

YUCCA.

Blight (*Cercospora floricola* Heald and Wolf, 32).—This disease produces on the yucca (*Yucca rupicola* Scheele) elongated grayish or brownish patches, which become darker with age and spread over the main scape, the flower pedicels, and the outer divisions of the perianth. The creamy-white outer perianth segments may be completely covered with the conidial tufts, which cause them to turn nearly black and to shrivel more or less. (Pl. XIX, fig. 3.) The fungus may spread over the whole segment from the tip downward. The perianth divisions may be attacked before the flower opens and the flower bud completely blighted (Pl. XIX, fig. 2), or the flower may expand to full size and open in a normal way, but blight completely a little later. In the locality where the disease was prevalent fruit formation did not take place.

Conidiophores in dense fascicles of many short, brown, continuous filaments, 30 to 45 by 5 to 6 μ ; spores generally straight, cylindrical, or slightly clavate, hyaline or faintly colored, 18 to 69 by 5 to 5.5 μ , and one to five septate, commonly three septate. (Pl. I, fig. 3.)

Specimen collected: On *Yucca rupicola* Scheele—Austin, 1488 (type specimen).

Leaf-spot (*Pestalotziella yuccae* Karst. and Har.).—Grayish lenticular areas, 4 to 10 mm. in length, are produced on the leaves. Protruding through the epidermis are dark pustules, the acervuli containing oblong clear spores with four hairs at the apex.

Specimen collected: On *Yucca rupicola* Scheele—Austin, 1530.

Leaf-blight (*Kellermannia yuccogena* Ell. and Kellerm.).—The affected leaves become straw colored, the dead area advancing downward from the tip or showing as a narrow zone along the margin. The advancing edge of the dead area is generally bordered by a narrow zone of brown. Our observations indicate that this species of fungus is not strictly parasitic, but that it finds its entrance first into leaves which have been scorched by prairie fires.

The pycnidia are very abundant on both surfaces, showing as minute black specks, 345 to 500 μ in diameter. Spores hyaline, two celled, 33 to 45 by 9 to 10.5 μ , each with a colorless appendage from the end, 15 to 30 μ long.

Specimen collected: On *Yucca filamentosa* L.—Sabinal, 1988.

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DESCRIPTION OF PLATES.

All drawings show a magnification of 417 diameters unless otherwise indicated.

PLATE I. Species of *Cercospora* from various hosts, No. 1. Fig. 1.—Three spores of *Cercospora vignae* Racib. on cowpea (*Vigna unguiculata* (L.) Walp.). Fig. 2.—Three spores of *C. cruenta* Sacc. on *Vigna unguiculata* (L.) Walp. Fig. 3.—Conidiophores and spores of *C. floricola* Heald and Wolf on *Yucca rupicola* Sheele; also three spores above. Fig. 4.—Conidiophores and spores of *C. atricincta* Heald and Wolf on zinnia (*Crassina elegans* (Jacq.) Kuntze). Fig. 5.—Conidiophores and spores of *C. lythracearum* Heald and Wolf on pomegranate (*Punica granatum* L. and Var.). Fig. 6.—Conidiophores and spores of *C. lythracearum* Heald and Wolf on crape myrtle (*Lagerstroemia indica* L.). Fig. 7.—Conidiophores and spores of *C. macromaculans* Heald and Wolf on *Syringa* sp. Fig. 8.—Conidiophores and spores of *C. aurantia* Heald and Wolf on orange (*Citrus aurantium sinensis* L.).

PLATE II. Species of *Cercospora* from various hosts, No. 2. Fig. 1.—Conidiophores and spores of *Cercospora nasturtii* Pass. on water cress (*Radicula nasturtium-aquaticum* (L.) Britten and Rendle). Fig. 2.—Conidiophores and spores of *C. lanuginosa* Heald and Wolf on *Bumelia lanuginosa* (Michx.) Pera. Fig. 3.—Conidiophores and spores of *C. nepheloides* Ell. and Holw. on Mexican blue-bell (*Eustoma russellianum* (Hook.) Griesb.). Fig. 4.—Conidiophores and spores of *C. xanthicola* Heald and Wolf on *Xanthium* sp. Fig. 5.—Diagram of a portion of a cross section of leaf showing abundance and distribution of conidial tufts of *C. canescens* Ell. and Martin on the Lima bean (*Phaseolus lunatus* L.) $\times 73$. Fig. 6.—Conidiophores and spores of *C. canescens* Ell. and Martin on the Lima bean (*P. lunatus* L.). Fig. 7.—Spores of *Cercospora bolleana* (Thm.) Speg. on the fig (*Ficus carica* L.). Fig. 8.—Conidiophores and spores *Cercospora fici* Heald and Wolf on the fig (*F. carica* L.).

PLATE III. Species of *Cercospora* from various hosts, No. 3. Fig. 1.—Conidiophores and spores of *Cercospora adusta* Heald and Wolf on California privet (*Ligustrum ovalifolium* Hassk.). Fig. 2.—Conidiophores and spores of *C. prosopidis* Heald and Wolf on mesquite (*Prosopis glandulosa* Torr.). Fig. 3.—Conidiophores and spores of *C. perniciosus* Heald and Wolf on buttonbush (*Oephalanthus occidentalis* L.). Fig. 4.—Conidiophores and spores of *C. chrysanthemi* Heald and Wolf on *Chrysanthemum* sp. Fig. 5.—Conidiophores and spores of *C. pustula* Cke. on Virginia creeper (*Pseodera quinquefolia* (L.) Greene). Fig. 6.—Conidiophores and spores of *C. obscura* Heald and Wolf on globe artichoke (*Cynara scolymus* L.). Fig. 7.—Conidiophores and spores of *C. fulvella* Heald and Wolf on crown-beard (*Verbesina texana* Buckl.). Fig. 8.—Spores of *C. viticola* (Ces.) Sacc. on *Vitis* sp. Fig. 9.—Conidiophores and spores of *C. personata* (B. and C.) Ell. on the peanut (*Arachis hypogaea* L.).

PLATE IV. Species of *Cercospora* from various hosts, No. 4. Fig. 1.—Conidiophores and spores of *Cercospora sagittariae* Ell. and Ev. on *Sagittaria* sp. Fig. 2.—Conidiophores and spores of *C. crataegi* Heald and Wolf on hawthorn (*Crataegus* sp.). Fig. 3.—Conidiophores and spores of *C. malachrae* Heald and Wolf on mallow (*Malachra capitata* L.). Fig. 4.—Spores of *C. elaeagni* Heald and Wolf on *Elaeagnus* sp. Fig. 5.—Conidiophores and spores of *C. physaliscola* Ell. and Barthol. on ground-cherry (*Physalis* sp.). Fig. 6.—Conidiophores and spores of *C. moricola* Cke. on red mulberry (*Morus rubra* L.). Fig. 7.—Conidiophores and spores of *C. capsici* Heald and Wolf on pepper (*Capsicum annuum* L.).

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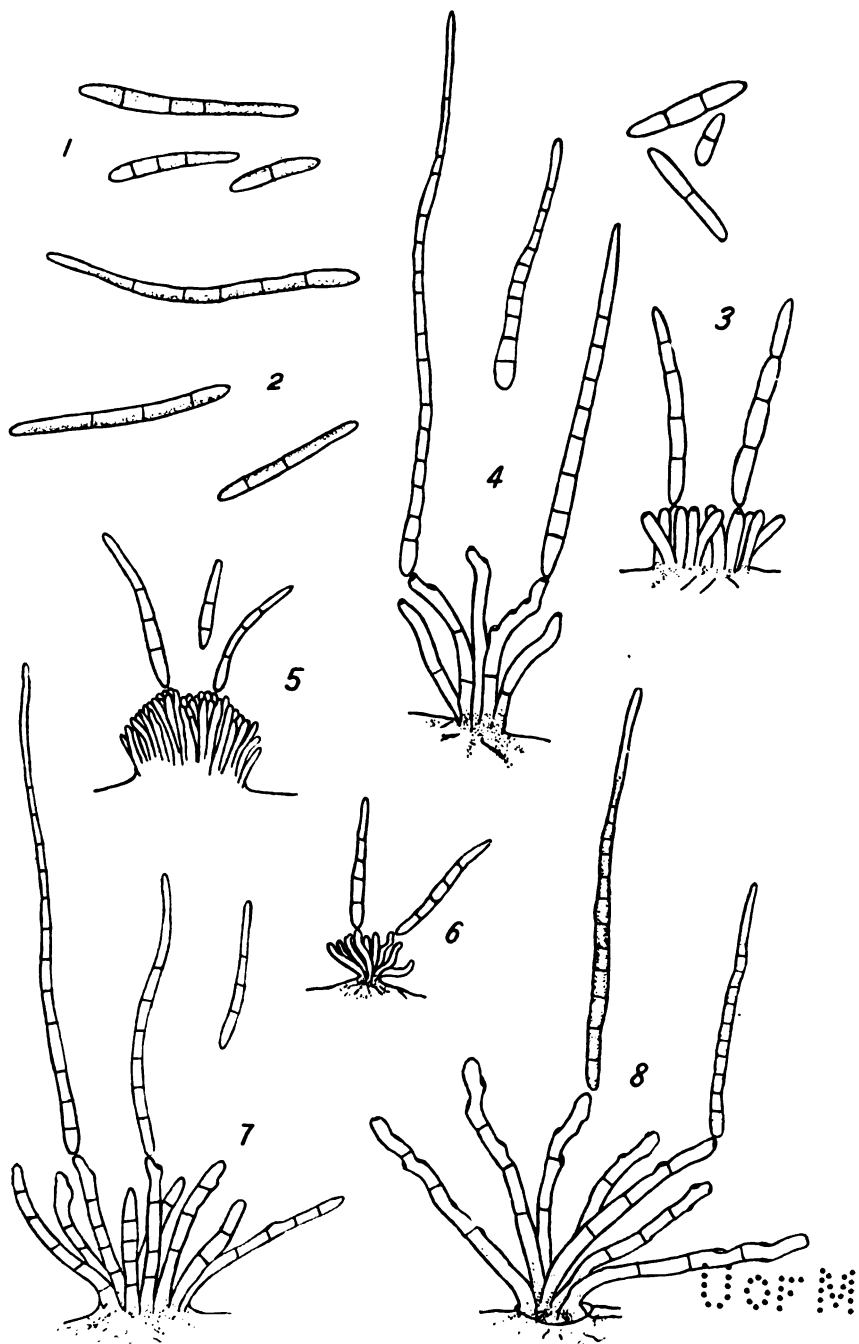
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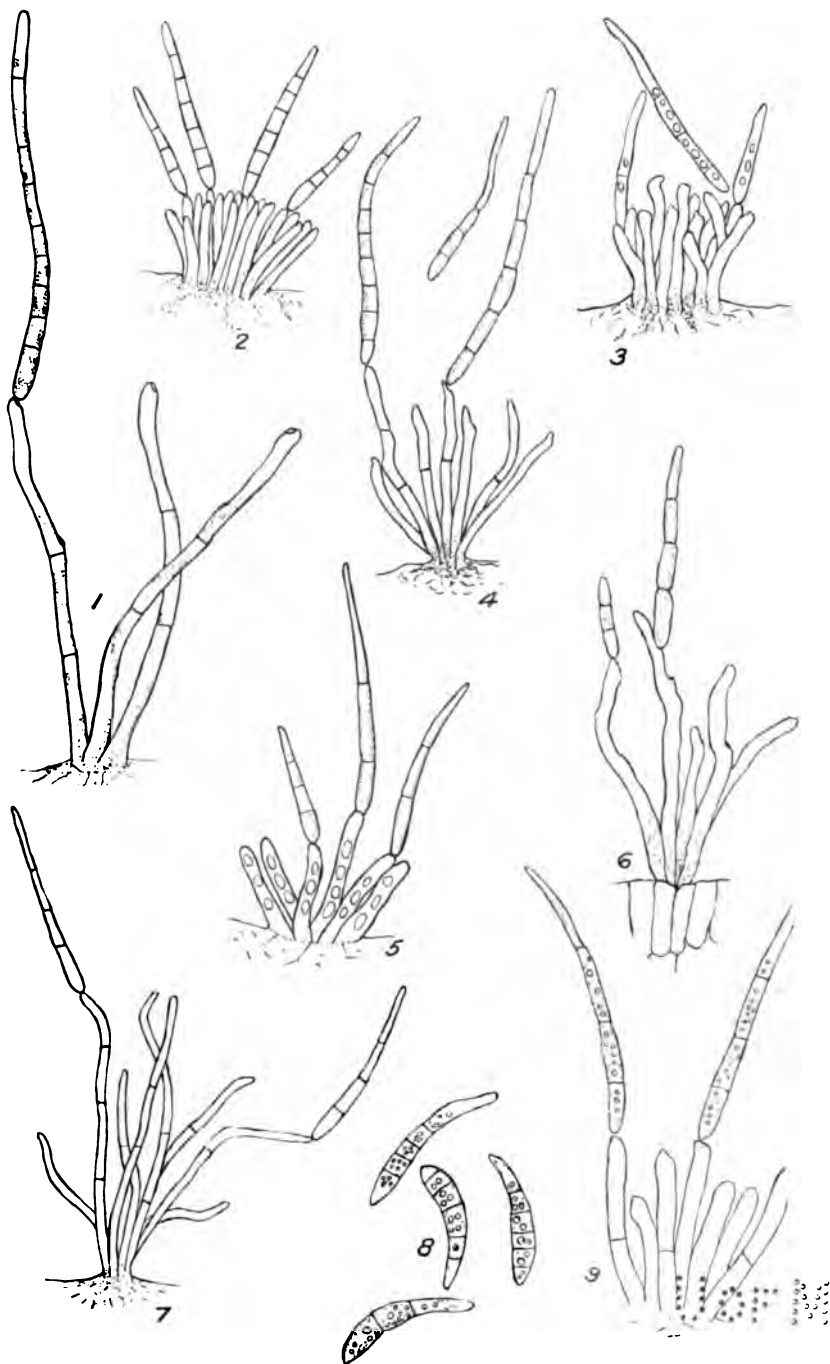
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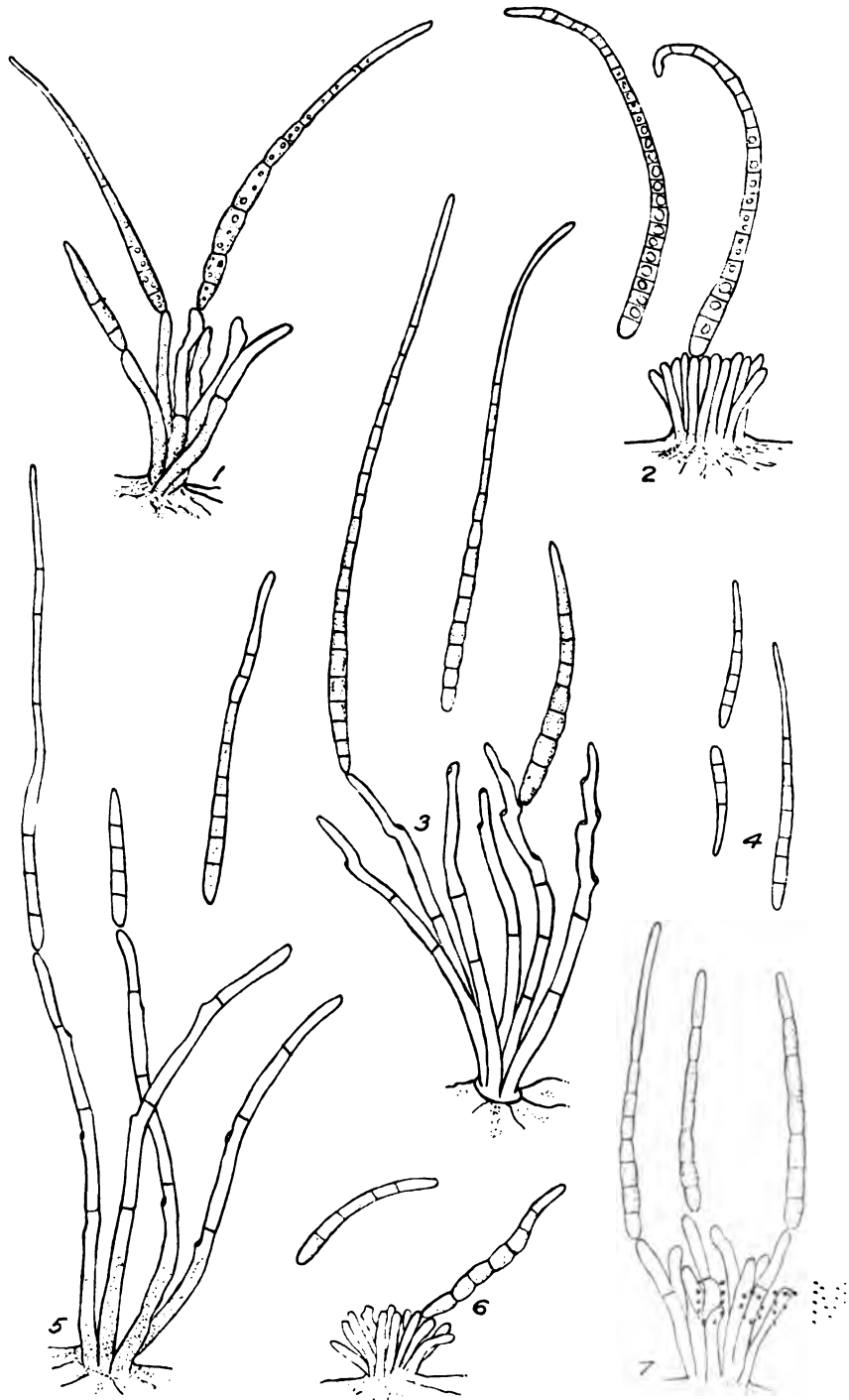
SPECIES OF CERCOSPORA FROM VARIOUS HOSTS, No. 1.

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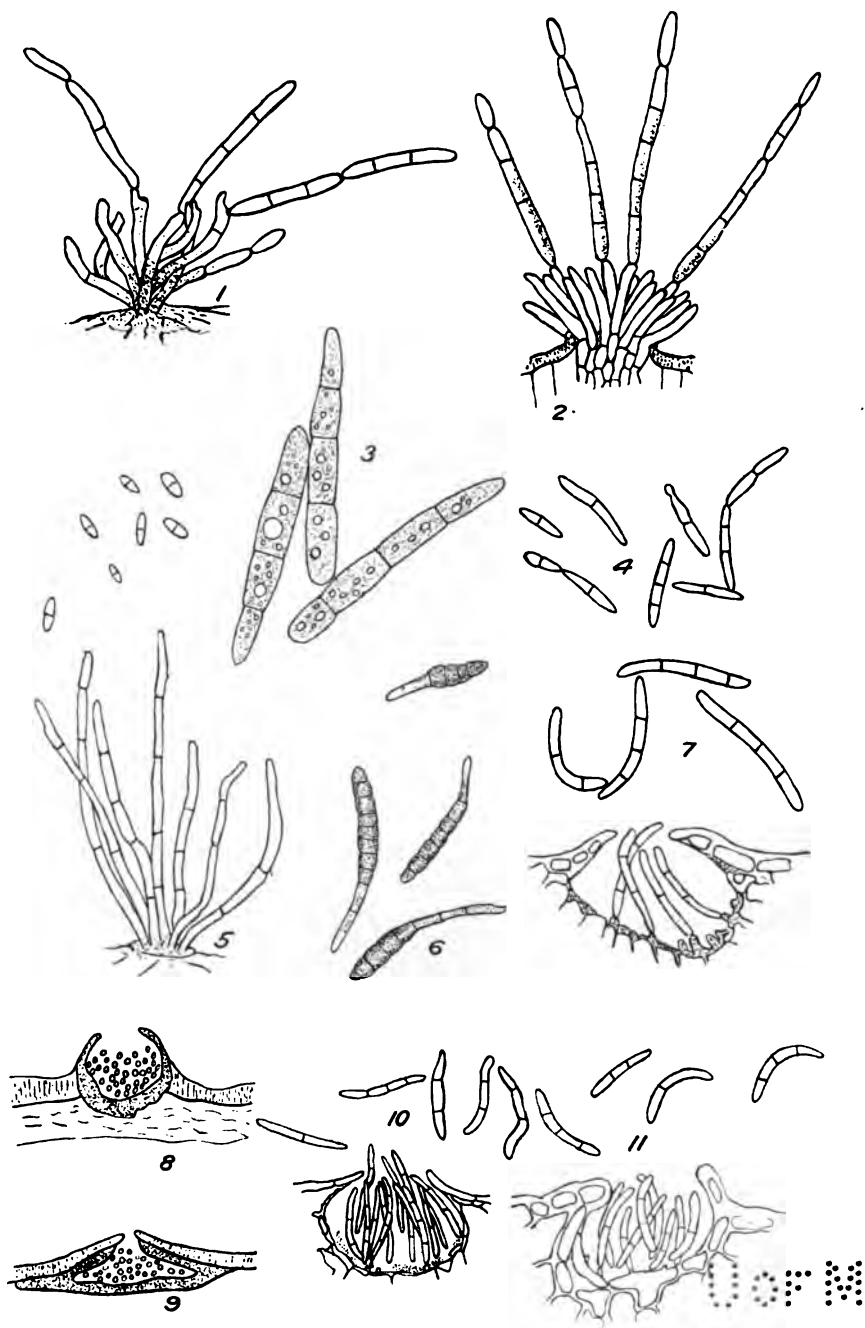
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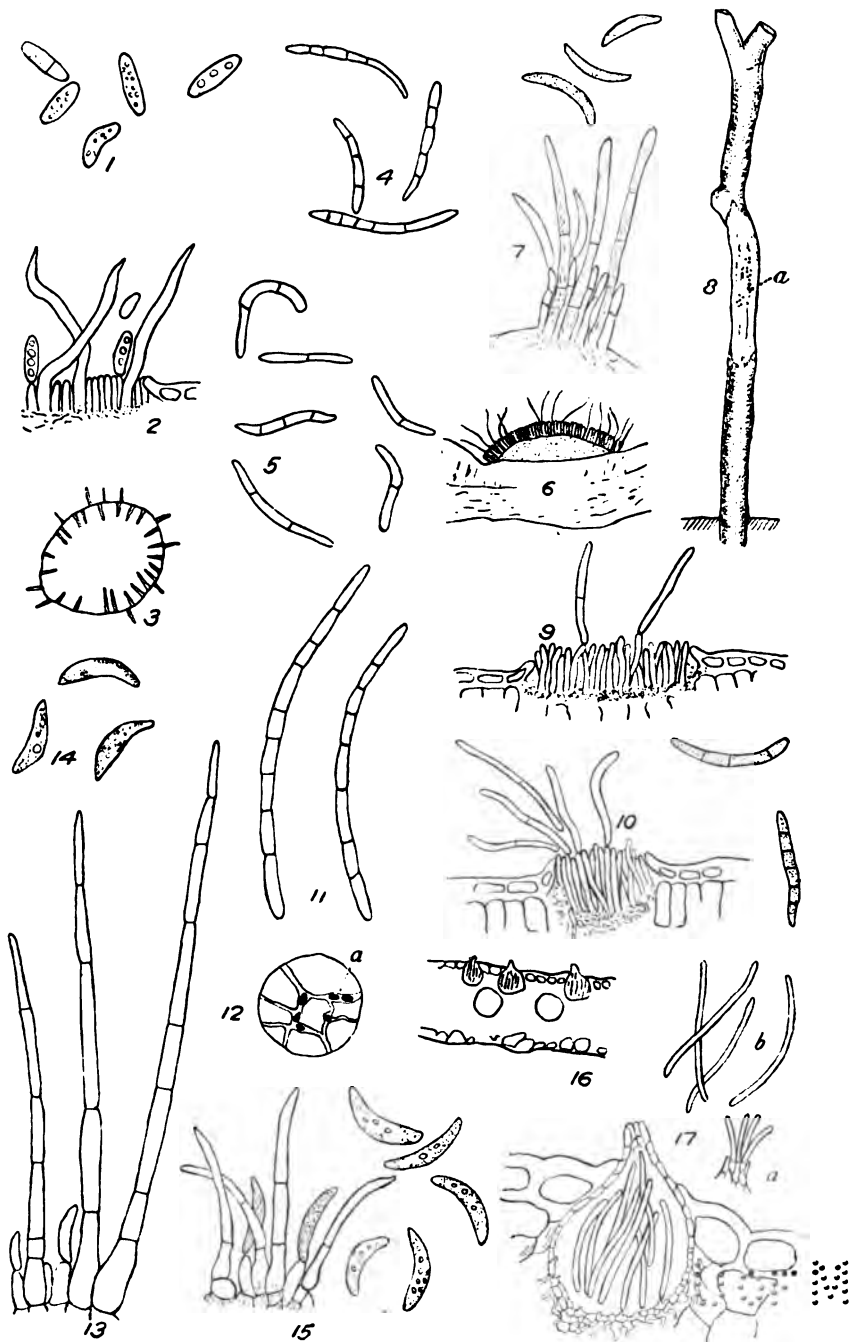
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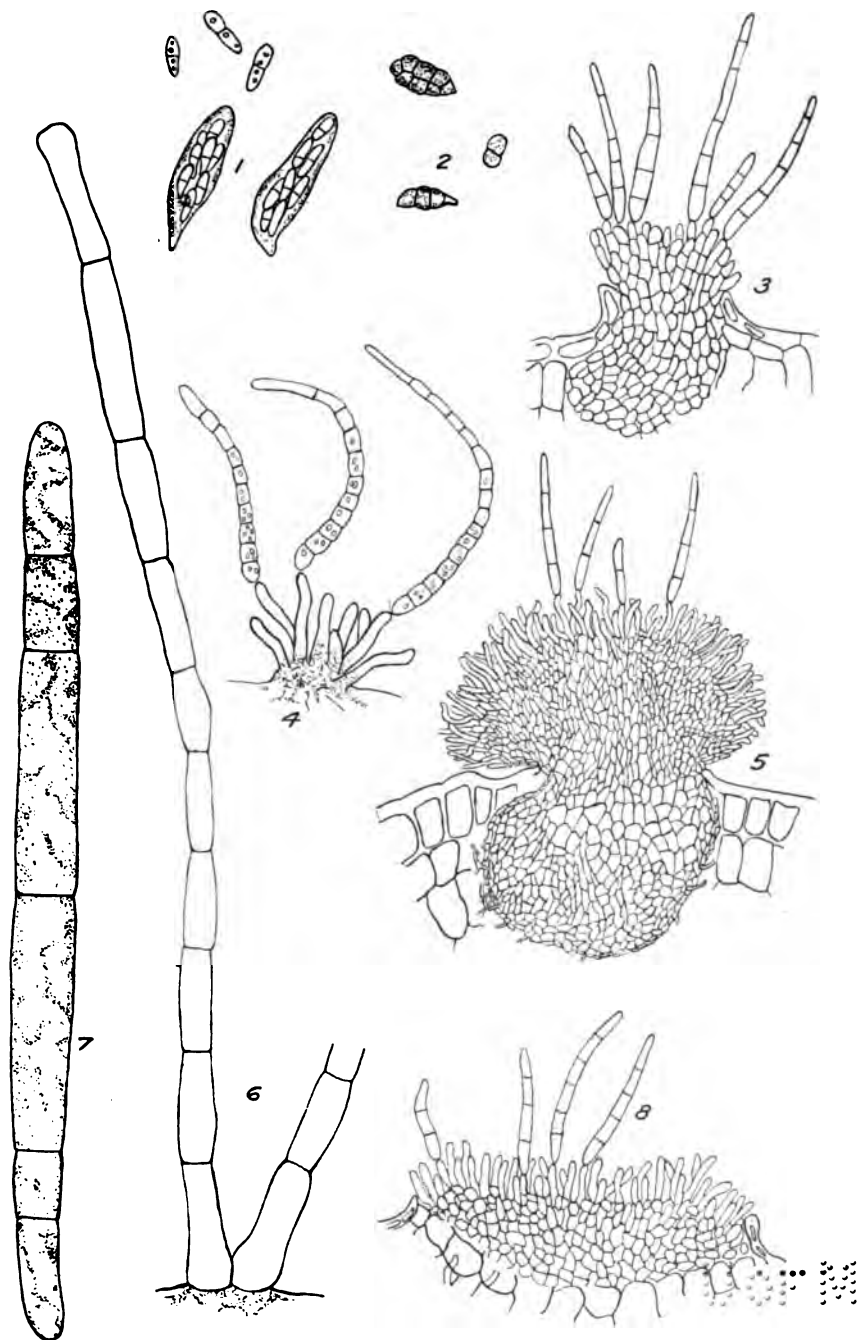
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SPECIES OF COLLETOTRICHUM, CYLINDROSPORIUM, AND SEPTORIA ON VARIOUS HOSTS.

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FUNGI FROM VARIOUS HOSTS.

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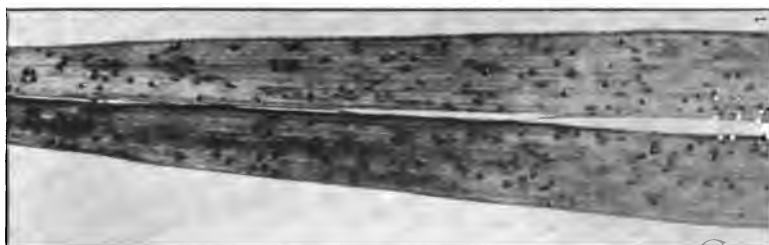
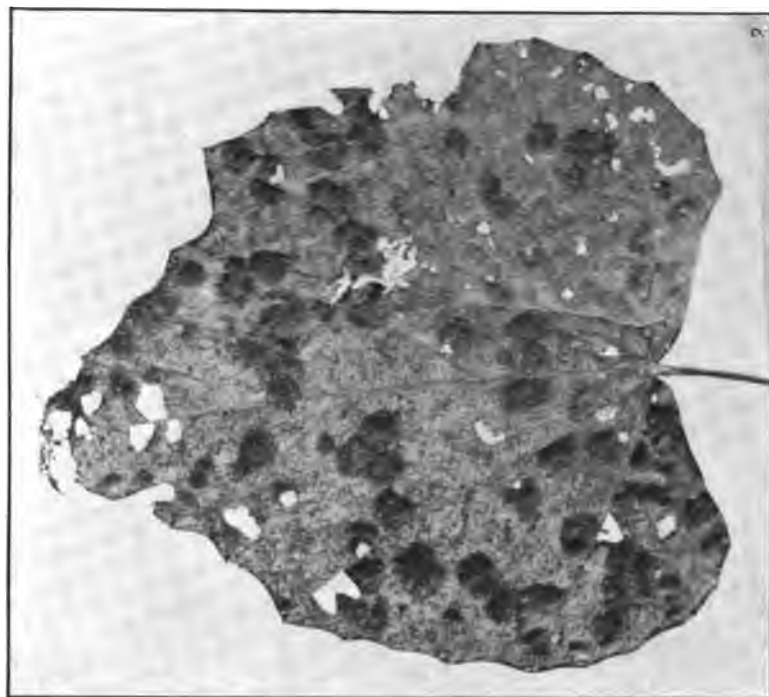
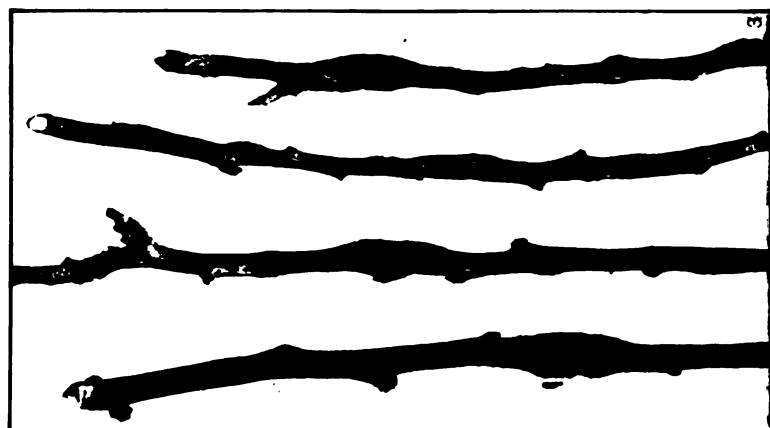


FIG. 1.—LEAFLET OF THE DATE PALM, SHOWING NUMEROUS PUSTULES OF *GRAPHIOLA PHOENICIS*.
 FIG. 2.—LEAF OF GRAPE, SHOWING NUMEROUS BLOTCHES DUE TO *CERCOSPORA VITICOLA*.
 FIG. 3.—BACTERIAL TWIG-CANKER OF THE PLUM.

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FIG. 1.—ROOTS OF TOMATO PLANT DEFORMED BY NEMATODES.

FIG. 2.—ROOT-KNOT OF MUSKMELON DUE TO NEMATODES.

FIG. 3.—LEAVES OF LIMA BEAN, SHOWING LEAF-SPOT DUE TO *CERCOSPORA CANESCENS*.

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FIG. 1.—YOUNG WATERMELONS AFFECTED WITH BLOSSOM-END BLIGHT AND ROT.
FIG. 2.—TUBER OF POTATO, SHOWING NODULES FORMED BY RHIZOCTONIA.
FIG. 3.—CYMLING ALMOST DESTROYED BY BOTRYTIS CINEREA.

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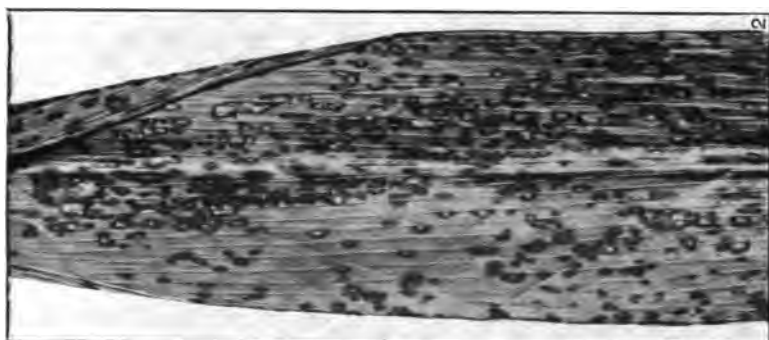


FIG. 1.—INFLORESCENCE OF FEATHER GRASS ATTACKED BY *BALANSIA HYPOXYLON*.
FIG. 2.—PORTION OF A LEAF OF SORGHUM AFFECTED WITH BLIGHT DUE TO *COLLETOTRICHUM LINEOLA*.
FIG. 3.—ROOTS OF COTTON AFFECTED WITH ROOT-ROT DUE TO A NEW SPECIES OF STERILE FUNGUS.

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FIG. 1.—LEAVES OF EUONYMUS, SHOWING THE CHARACTERISTIC SPOTTING CAUSED BY EXOSPORIUM CONCENTRICUM.



FIG. 2.—LEAVES OF EUONYMUS, SHOWING SPOTS DUE TO COLLETOTRICHUM GRISEUM.

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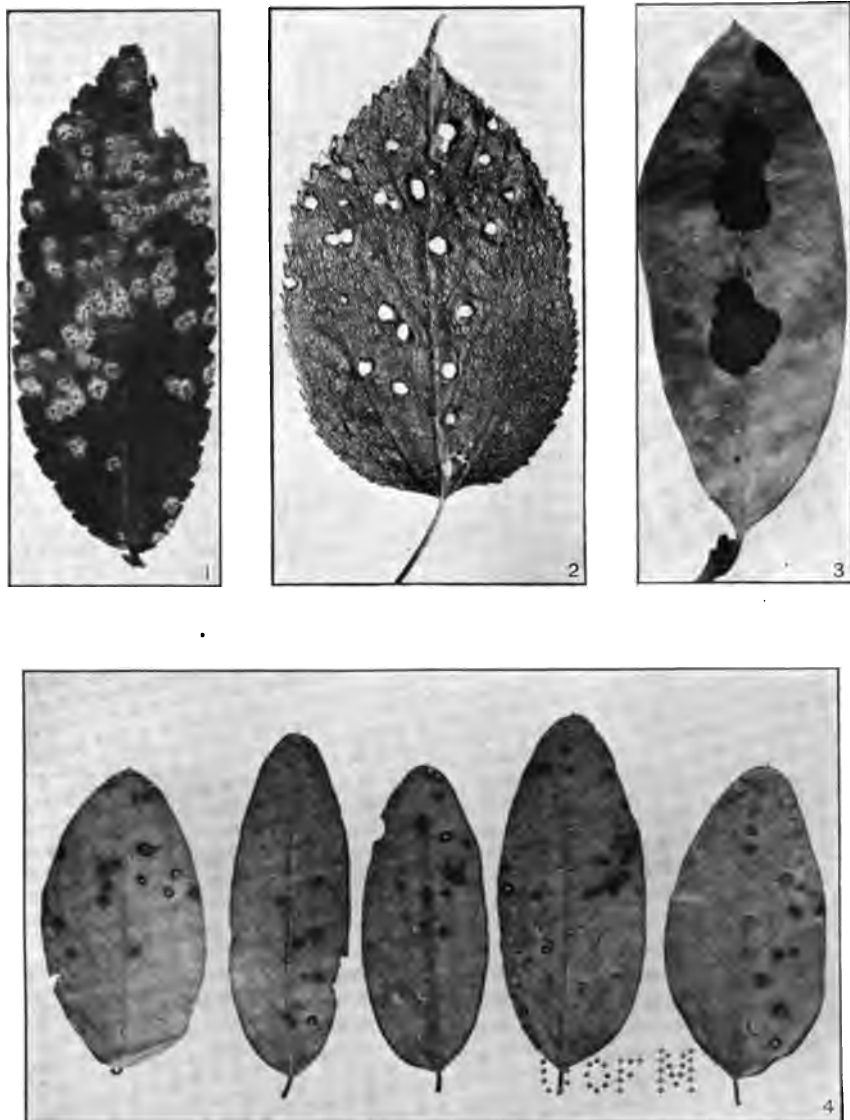


FIG. 1.—LEAF OF WINGED ELM AFFECTED WITH SCAB DUE TO *GNOMONIA ULMEA*.
FIG. 2.—LEAF OF RED MULBERRY, SHOWING EYE-SPOT DUE TO *CERCOSPORA MORICOLA*.
FIG. 3.—LEAF OF LIVE OAK, SHOWING TAR-SPOT DUE TO *RHYTISMA ERYTHROSPORIUM*.
FIG. 4.—LEAFLETS OF BLACK LOCUST, SHOWING THE CHARACTERISTIC SPOTTING DUE TO *CYLINDROSPORIUM SOLITARUM*.

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FIG. 1.—LEAVES OF THE HACKBERRY BLIGHTED BY *CYLINDROSPORIUM DEFOLIATUM*.



FIG. 2.—LEAF OF THE SYCAMORE BLIGHTED BY *PHLEOSPORA MULTUMACULANS*.

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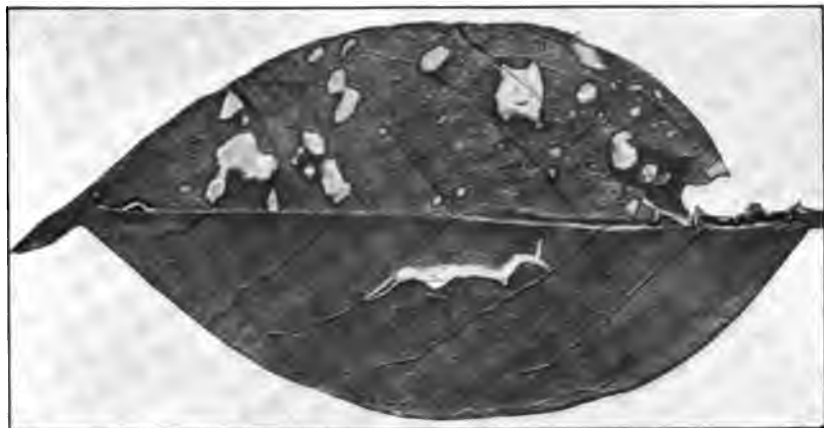


FIG. 1.—LEAF OF THE JAPANESE PRIVET AFFECTED WITH LEAF-SPOT DUE TO *CERCOSPORA LIGUSTRI*.



FIG. 2.—SMALL BRANCH OF MESQUITE, SHOWING THREE GALLS OF POSSIBLE BACTERIAL ORIGIN.

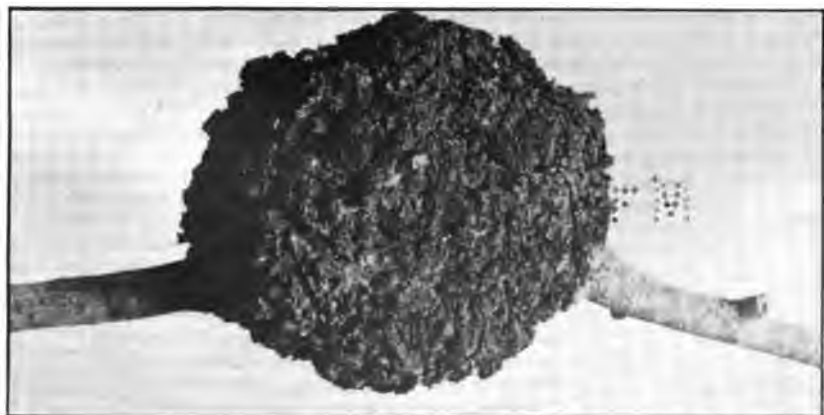


FIG. 3.—A SINGLE LARGE GALL ON A SMALL BRANCH OF MESQUITE.

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FIG. 1.—PORTION OF LEAF OF CENTURY PLANT AFFECTED WITH BLIGHT DUE TO *STAGONOSPORA GIGANTEA*.

FIG. 2.—MARGIN OF SAME LEAF SLIGHTLY ENLARGED, SHOWING THE DISTRIBUTION OF PYCNIDIA.

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FIG. 1.—LEAVES OF GERANIUM AFFECTED WITH BACTERIAL BLIGHT.



FIG. 2.—LEAF OF BEGONIA AFFECTED WITH BACTERIAL BLIGHT.

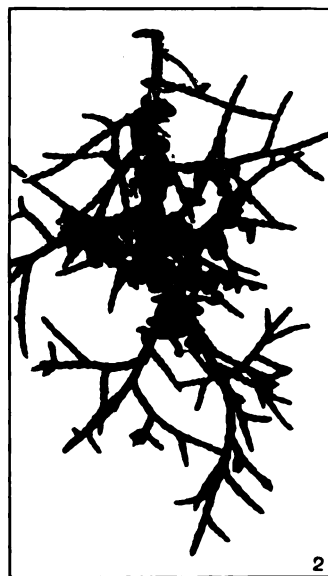


FIG. 1.—LEAF OF WILD MORNING-GLORY ATTACKED BY *ALBUGO IPOMOEAE-PANDURANAE*.
 FIG. 2.—SMALL BRANCH OF MOUNTAIN CEDAR, SHOWING THE GELATINOUS SORI OF
GYMNOSPORANGIUM EXIGUUM.
 FIG. 3.—LEAF-CURL OF TROMPILLO DUE TO NEMATODES.

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FIG. 1.—LEAFLET OF THE WILD CHINA TREE AFFECTED WITH *CYLINDROSPORIUM GRISEUM*.



FIG. 2.—BUDS OF *YUCCA* BLIGHTED BY *CERCOSPORA FLORICOLA*.



FIG. 3.—INFLORESCENCE OF *YUCCA* BLIGHTED BY *CERCOSPORA FLORICOLA*.

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